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ABB Flexible Automation AB
Product Manual IRB 6400R M99, On-line Manual

MAIN MENU

CONTENTS

Introduction

1 How to use this Manual

This manual provides information on installation, preventive maintenance, trouble-shooting and how to carry out repairs on the manipulator and controller. Its intended audience is trained maintenance personnel with expertise in both mechanical and electrical systems. The manual does not in any way assume to take the place of the maintenance course offered by ABB Flexible Automation.

Anyone reading this manual should also have access to the User's Guide.

The chapter entitled System Description provides general information on the robot structure, such as its computer system, input and output signals, etc.

How to assemble the robot and install all signals, etc., is described in the chapter on Installation and Commissioning.

If an error should occur in the robot system, you can find out why it has happened in the chapter on Troubleshooting. If you receive an error message, you can also consult the chapter on System and Error Messages in the User's Guide. It is very helpful to have a copy of the circuit diagram at hand when trying to locate cabling faults.

Servicing and maintenance routines are described in the chapter on Maintenance.

2 What you must know before you use the Robot

- Normal maintenance and repair work usually only require standard tools. Some repairs, however, require specific tools. These repairs, and the type of tool required, are described in more detail in the chapter Repairs.
- The power supply must always be switched off whenever work is carried out in the controller cabinet. Note that even though the power is switched off, the orange-coloured cables may be live. The reason for this is that these cables are connected to external equipment and are consequently not affected by the mains switch on the controller.
- Circuit boards - printed boards and components - must never be handled without Electro-Static Discharge (ESD) protection in order not to damage them. Use the carry band located on the inside of the controller door.

⚠ **All personnel working with the robot system must be very familiar with the safety regulations outlined in the chapter on Safety. Incorrect operation can damage the robot or injure someone.**

3 Identification

Identification plates indicating the type of robot and serial number, etc., are located on the manipulator (see Figure 1) and on the front of the controller (see Figure 2).

The BaseWare O.S diskettes are also marked with serial number (see Figure 3).

Note! The identification plates and label shown in the figures below, only serves as examples. For exact identification see plates on your robot in question.

ABB Robotics Products AB
S-721 68 Västerås Sweden Made in Sweden

Type:	IRB 6400R M99
Robot version:	IRB 6400/2.5-150
Man. order:	XXXXXX
Nom. load	See instructions
Serial. No:	**64-15XXX**
Date of manufacturing:	1999-XX-XX
Net weight 2,5-150 : 1910 kg	

Identification plate showing the IRB 6400R / M99

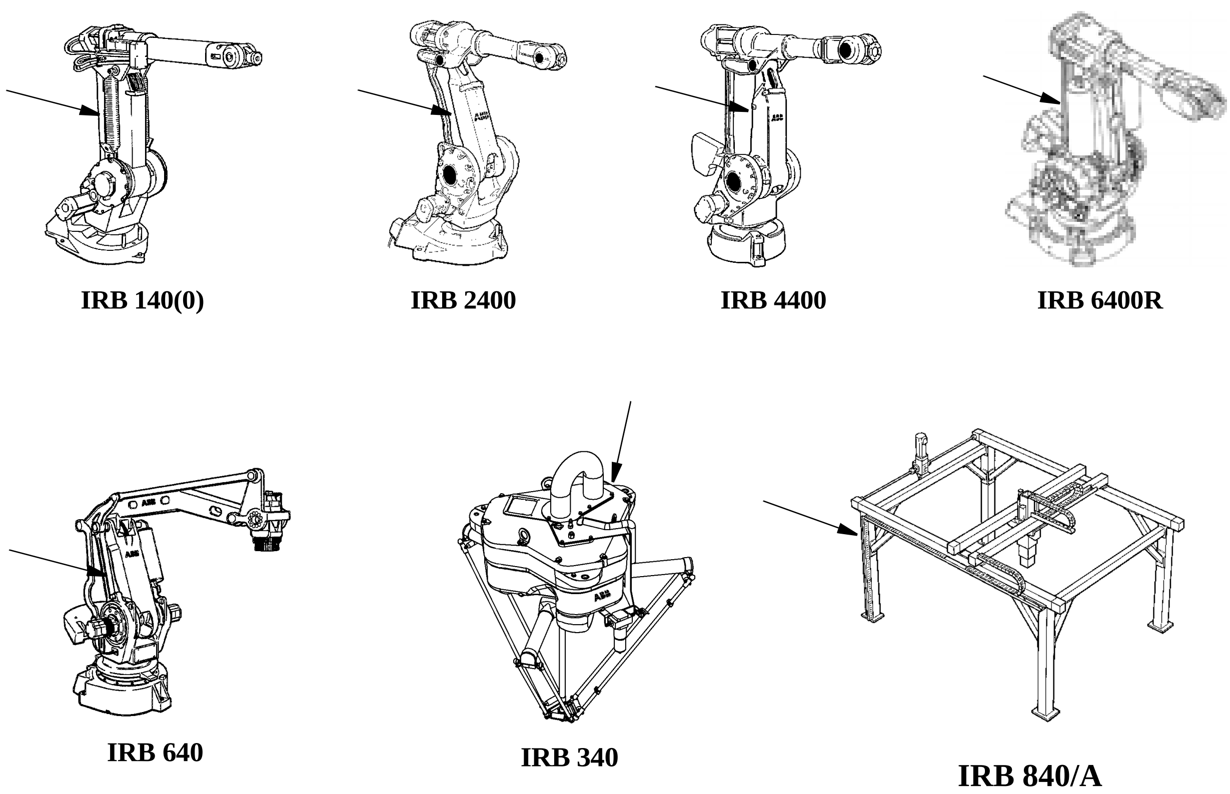


Figure 1 Examples of identification plate and its location on different manipulator types.

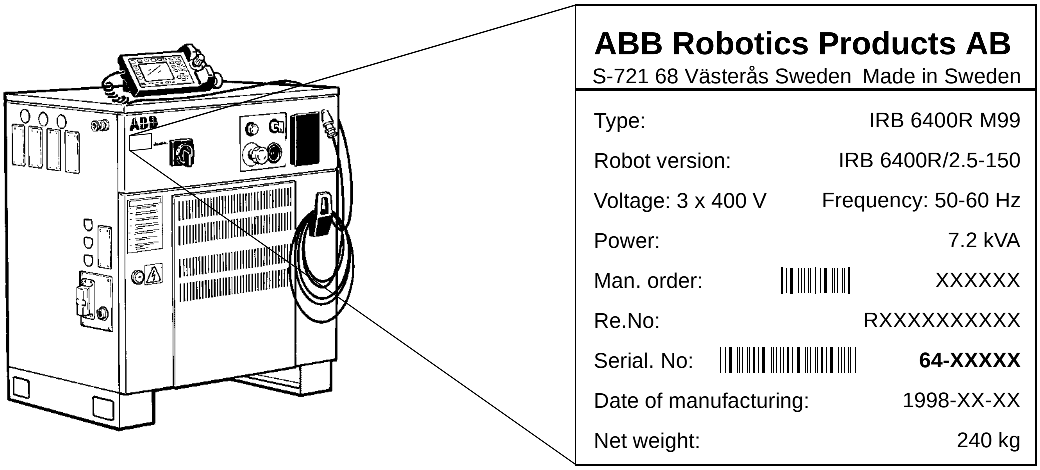


Figure 2 Identification plate on the controller.

64-00000
System Key S4C 3.1
Program No 3 HAB2390-1/03
Boot disk 1 (1)

Property of ABB Västerås/Sweden. All rights reserved. Reproduction, modification, use or disclosure to third parties without express authority is strictly forbidden. Copyright 1993. Restricted to be used in the controller(s) with the serial no as marked on disk.

ABB Robotics Products AB

Figure 3 Example of a label on a BaseWare O.S diskette.

CONTENTS

1 Introduction

Thank you for your interest in the IRB 6400R. This manual will give you an overview of the characteristics and performance of the robot.

IRB 6400R is a 6-axis industrial robot, designed specifically for manufacturing industries that use flexible robot-based automation. The robot has an open structure that is specially adapted for flexible use, and can communicate extensively with external systems.

The IRB 6400R comes in several different versions, with handling capacities of up to 200 kg, a maximum reach of 3 m, floor-mounted manipulators as well as manipulators for harsh environments.

Extra equipment, such as transformers and valve packages, can be placed on the upper arm or on the frame of axis 1 (see Chapter 3.4).

The robot can be supplied with an integrated spot welding harness as well as a mechanical support for externally mounted process solutions.

The robot is equipped with an operating system called BaseWare OS. BaseWare OS controls every aspect of the robot, like motion control, development and execution of application programs, communication etc.

The functions in this document are all included in BaseWare OS, if not otherwise specified. For additional functionality the robot can be equipped with optional software for application support - spot welding, gluing etc., communication features - network communication - and advanced functions - multitasking, sensor control etc. For a complete description of optional software, see the Product Specification RobotWare.

All the features are not described in this document. For a more complete and detailed description, please see the User’s Guide, RAPID Reference Manual and Product Manual, or contact your nearest ABB Flexible Automation Centre.

Accessories, such as track motion, motors for external axes, cabling for spot welding guns, and tool systems with tool exchangers, have been specially adapted for use with the IRB 6400R (see Chapter 5).

Different robot versions

The IRB 6400R, as mentioned above, is available in several different versions.
The following different robot types are available:

IRB 6400R/2.5-120
IRB 6400R/2.5-150
IRB 6400R/2.5-200

IRB 6400R/2.8-150
IRB 6400R/2.8-200
IRB 6400R/3.0-100

Definition of version designation

IRB 6400R Mounting/ Reach - Handling capacity

	Prefix	Description
Mounting	-	Floor-mounted manipulator
Reach	x.x	Indicates the maximum reach at wrist centre (m)
Handling capacity	yyy	Indicates the maximum handling capacity (kg)

How to use this manual

The characteristics of the robot are described in Chapter 2: *Description*.

The most important technical data is listed in Chapter 3: *Technical specification*.

Note that the sections in chapters 2 and 3 are related to each other. For example, in section 2.2 you can find an overview of safety and standards, in section 3.2 you can find more detailed information.

To make sure that you have ordered a robot with the correct functionality, see Chapter 4: *Specification of Variants and Options*.

In Chapter 5 you will find accessories for the robot.

Chapter 6 contains an *Index*, to make things easier to find.

Other manuals

The User's Guide is a reference manual with step by step instructions on how to perform various tasks.

The programming language is described in the RAPID Reference Manual.

The Product Manual describes how to install the robot, as well as maintenance procedures and troubleshooting.

The Product Specification RobotWare describes the software options.

2 Description

2.1 Structure

The robot is made up of two main parts: a manipulator and a controller.

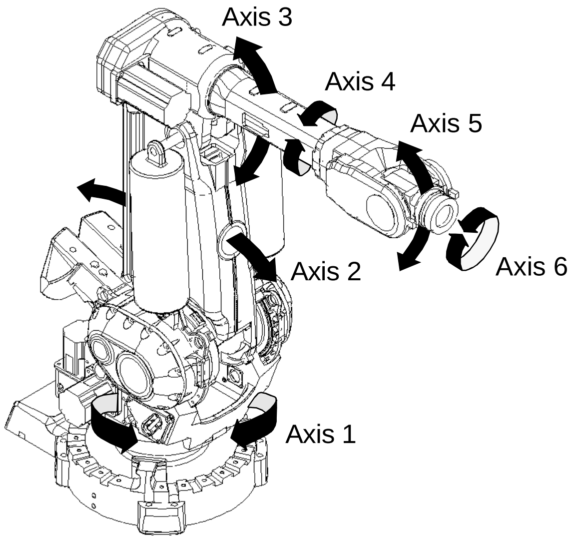


Figure 1 The IRB 6400R manipulator has 6 axes.

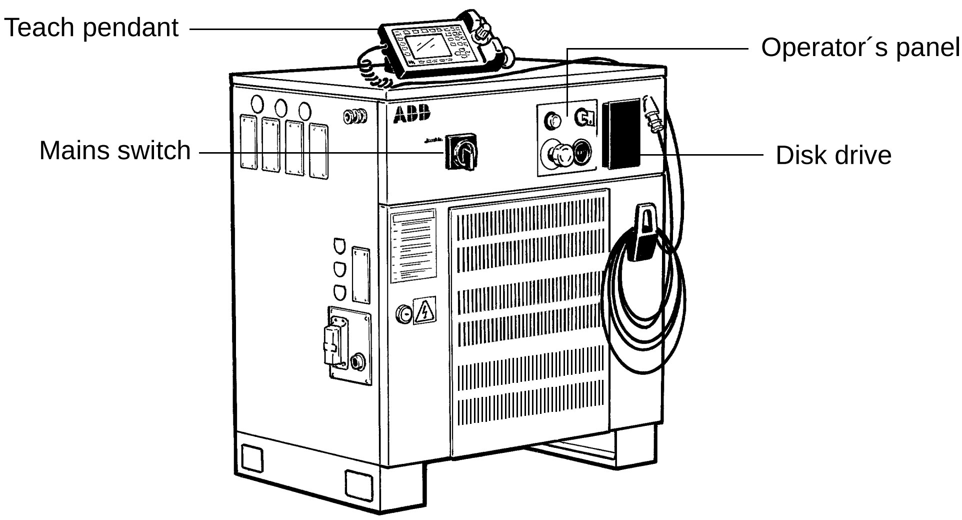


Figure 2 The controller is specifically designed to control robots, which means that optimal performance and functionality is achieved.

The controller contains the electronics required to control the manipulator, external axes and peripheral equipment.

2.2 Safety/Standards

The robot complies fully with the health and safety standards specified in the EEC's Machinery Directives. For other safety standards, see chapter 3.2 on page 21.

The robot is designed with absolute safety in mind. It has a dedicated safety system based on a two-channel circuit which is monitored continuously. If any component fails, the electrical power supplied to the motors shuts off and the brakes engage.

Safety category 3
Malfunction of a single component, such as a sticking relay, will be detected at the next MOTOR OFF/MOTOR ON operation. MOTOR ON is then prevented and the faulty section is indicated. This complies with category 3 of EN 954-1, Safety of machinery - safety related parts of control systems - Part 1.

Selecting the operating mode
The robot can be operated either manually or automatically. In manual mode, the robot can only be operated via the teach pendant, i.e. not by any external equipment.

Reduced speed
In manual mode, the speed is limited to a maximum of 250 mm/s (600 inch/min.). The speed limitation applies not only to the TCP (Tool Centre point), but to all parts of the robot. It is also possible to monitor the speed of equipment mounted on the robot.

Three position enabling device
The enabling device on the teach pendant must be used to move the robot when in manual mode. The enabling device consists of a switch with three positions, meaning that all robot movements stop when either the enabling device is pushed fully in, or when it is released completely. This makes the robot safer to operate.

Safe manual movement
The robot is moved using a joystick instead of the operator having to look at the teach pendant to find the right key.

Over-speed protection
The speed of the robot is monitored by two independent computers.

Emergency stop
There is one emergency stop push button on the controller and another on the teach pendant. Additional emergency stop buttons can be connected to the robot's safety chain circuit.

Safeguarded space stop
The robot has a number of electrical inputs which can be used to connect external safety equipment, such as safety gates and light curtains. This allows the robot's safety functions to be activated both by peripheral equipment and by the robot itself.

Delayed safeguarded space stop
A delayed stop gives a smooth stop. The robot stops in the same way as at a normal program stop with no deviation from the programmed path. After approx. 1 second the power supplied to the motors shuts off.

Collision detection
In case an unexpected mechanical disturbance like a collision, electrode stik etc appears, the robot will stop and slightly back off from its stop position.

Restricting the working space
The movement of each axis can be restricted using software limits. Axes 1-3 can also be restricted by means of mechanical stops.

Hold-to-run control
"Hold-to-run" means that you must depress the start button in order to move the robot. When the button is released the robot will stop. The hold-to-run function makes program testing safer.

Fire safety
Both the manipulator and control system comply with UL's (Underwriters Laboratory) tough requirements for fire safety.

Safety lamp
As an option, the robot can be equipped with a safety lamp mounted on the manipulator. This is activated when the motors are in the MOTORS ON state.

2.3 Operation

All operations and programming can be carried out using the portable teach pendant (see Figure 3) and the operator's panel (see Figure 5).

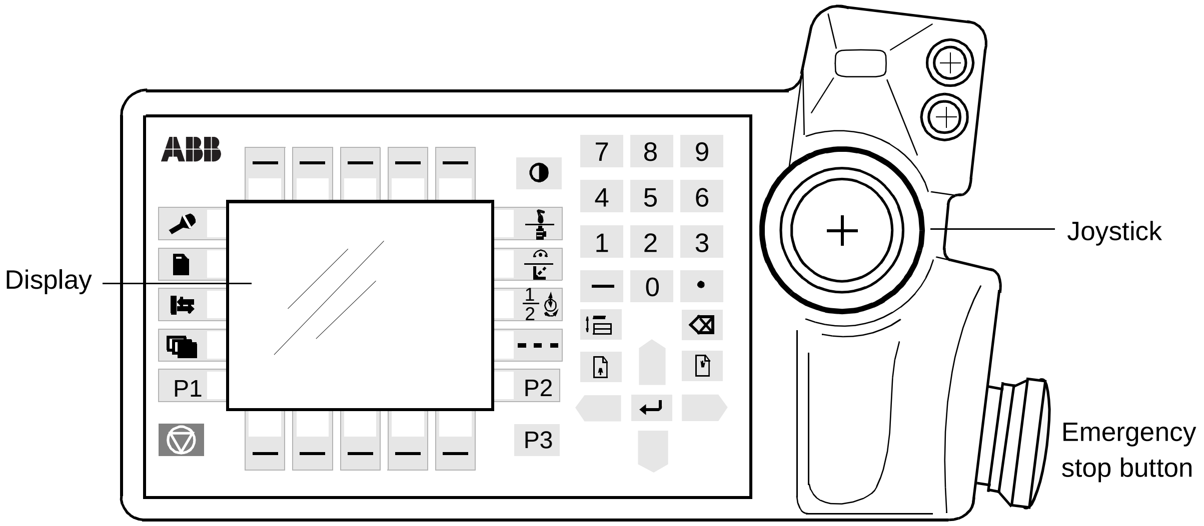


Figure 3 The teach pendant is equipped with a large display, which displays prompts, information, error messages and other information in plain English.

Information is presented on a display using windows, pull-down menus, dialogs and function keys. No previous programming or computer experience is required to learn how to operate the robot. All operations can be carried out from the teach pendant, which means that an additional keyboard is not required. All information, including the complete programming language, is in English or, if preferred, some other major language. (For a list of languages, see Product Specification RobotWare).

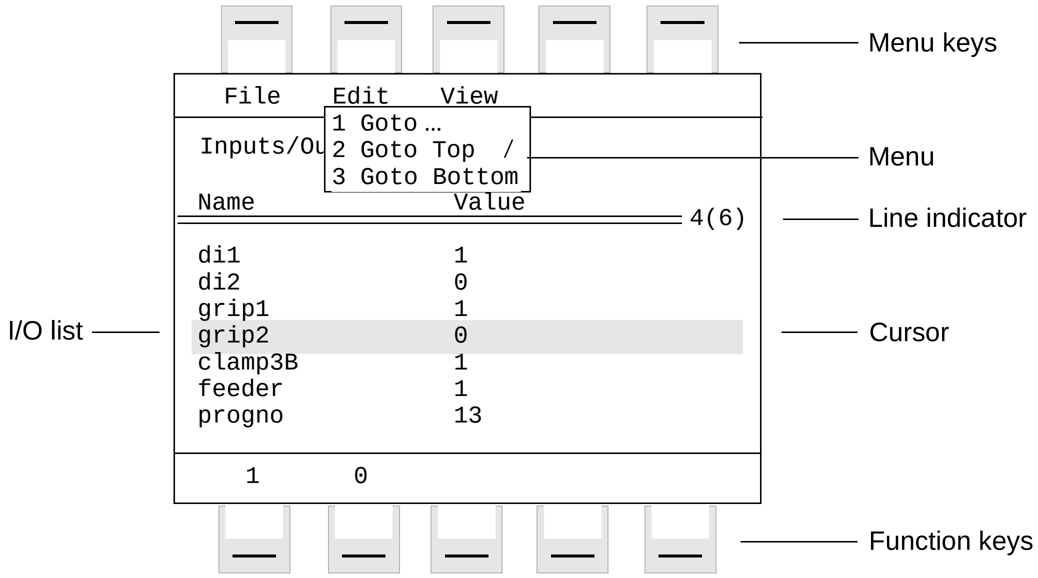


Figure 4 Window for manual operation of input and output signals.

Using the joystick, the robot can be manually jogged (moved). The user determines the speed of this movement; large deflections of the joystick will move the robot quickly, smaller deflections will move it more slowly.

The robot supports different user tasks, with dedicated windows for:

- Production
- Programming
- System setup
- Service and installation

Operator's panel

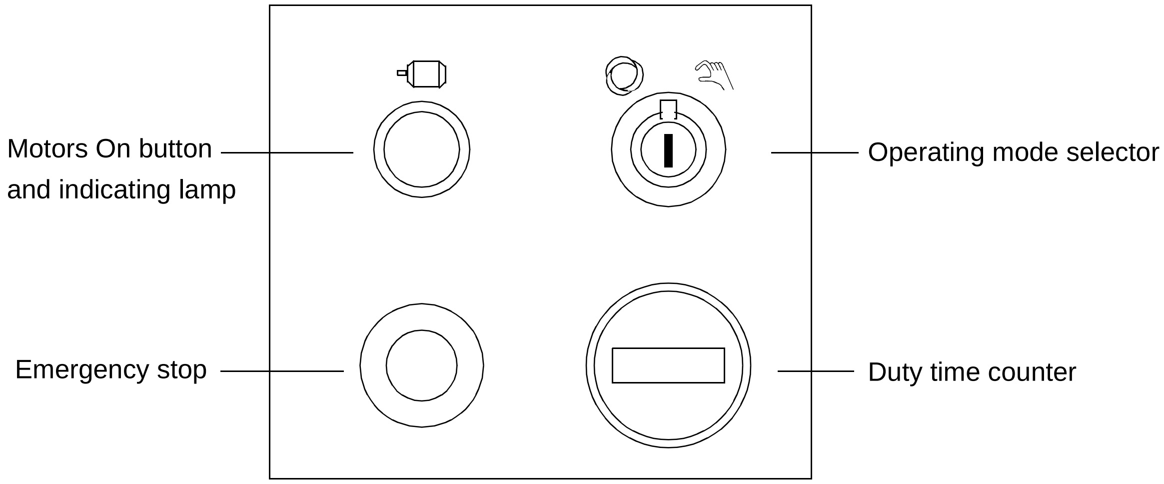


Figure 5 The operating mode is selected using the operator's panel on the controller.

Using a key switch, the robot can be locked in two or three different operating modes depending on chosen mode selector:

	• Automatic mode:	Running production
	• Manual mode at reduced speed:	Programming and setup Max. speed: 250 mm/s (600 inches/min.)
100%	• Manual mode at full speed (option): Equipped with this mode, the robot is not approved according to ANSI/UL	Testing at full program speed

Both the operator’s panel and the teach pendant can be mounted externally, i.e. outside the cabinet. The robot can then be controlled from there.

The robot can be remotely controlled from a computer, PLC or from a customer’s panel, using serial communication or digital system signals.

For more information on how to operate the robot, see the User’s Guide.

2.4 Installation

The robot has a standard configuration and can be operated immediately after installation. Its configuration is displayed in plain language and can easily be changed using the teach pendant. The configuration can be stored on a diskette and/or transferred to other robots that have the same characteristics.

All the versions of IRB 6400R are designed for floor mounting. Depending on the robot version an end effector of max. weight 100 to 200 kg, including payload, can be mounted on the mounting flange (axis 6). Load diagram, see chapter 3.4.

Extra loads (valve packages, transformers) can be mounted on the upper arm. On all versions an extra load can also be mounted on the frame of axis 1. Holes for extra equipment are described in chapter 3.4.

The working range of axes 1-3 can be limited by mechanical stops. Position switches can be supplied on axes 1-3 for position indication of the manipulator.

2.5 Programming

Programming the robot involves choosing instructions and arguments from lists of appropriate alternatives. Users do not need to remember the format of instructions, since they are prompted in plain English. “See and pick” is used instead of “remember and type”.

The programming environment can be easily customized using the teach pendant.

- Shop floor language can be used to name programs, signals, counters, etc.
- New instructions can be easily written.
- The most common instructions can be collected in easy-to-use pick lists.
- Positions, registers, tool data, or other data, can be created.

Programs, parts of programs and any modifications can be tested immediately without having to translate (compile) the program.

The program is stored as a normal PC text file, which means that it can be edited using a standard PC.

Movements

A sequence of movements is programmed as a number of partial movements between the positions to which you want the robot to move.

The end position of a movement is selected either by manually jogging the robot to the desired position with the joystick, or by referring to a previously defined position.

The exact position can be defined (see Figure 6) as:

- a stop point, i.e. the gantry robot reaches the programmed position

  or

- a fly-by point, i.e. the robot passes close to the programmed position. The size of the deviation is defined independently for the TCP, the tool orientation and the external axes.

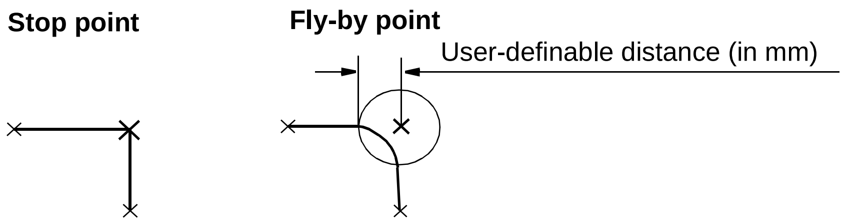


Figure 6 The fly-by point reduces the cycle time since the robot does not have to stop at the programmed point. The path is speed independent.

The velocity may be specified in the following units:

- mm/s
- seconds (time it takes to reach the next programmed position)
- degrees/s (for reorientation of the tool or for rotation of an external axis)

Program management

For convenience, the programs can be named and stored in different directories.

Areas of the robot’s program memory can also be used for program storage. This provides fast memory for program storage. These can then be automatically downloaded using a program instruction. The complete program or parts of programs can be transferred to/from a diskette.

Programs can be printed on a printer connected to the robot, or transferred to a PC where they can be edited or printed later.

Editing programs

Programs can be edited using standard editing commands, i.e. “cut-and-paste”, copy, delete, find and change, undo etc. Individual arguments in an instruction can also be edited using these commands.

No reprogramming is necessary when processing left-hand and right-hand parts, since the program can be mirrored in any plane.

A robot position can easily be changed either by

- jogging the robot with the joystick to a new position and then pressing the “ModPos” key (this registers the new position)

  or by

- entering or modifying numeric values.

To prevent unauthorised personnel from making program changes, passwords can be used.

Testing programs

Several helpful functions can be used when testing programs. For example, it is possible to

- start from any instruction
- execute an incomplete program
- run a single cycle
- execute forward/backward step-by-step
- simulate wait conditions
- temporarily reduce the speed
- change a position
- tune (displace) a position during program execution.

For more information, see the User’s Guide and RAPID Reference Manual.

2.6 Automatic Operation

A dedicated production window with commands and information required by the operator is automatically displayed during automatic operation.

The operation procedure can be customised to suit the robot installation by means of user-defined operating dialogs.

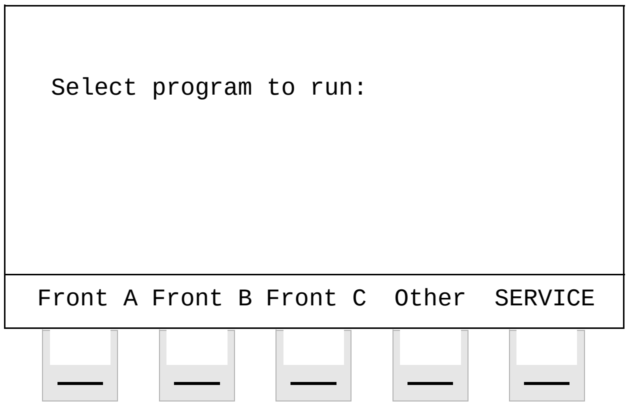


Figure 7 The operator dialogs can be easily customised.

A special input can be set to order the robot to go to a service position. After service, the robot is ordered to return to the programmed path and continue program execution.

You can also create special routines that will be automatically executed when the power is switched on, at program start and on other occasions. This allows you to customise each installation and to make sure that the robot is started up in a controlled way.

The robot is equipped with absolute measurement, making it possible to operate the robot directly when the power is switched on. For your convenience, the robot saves the used path, program data and configuration parameters so that the program can be easily restarted from where you left off. Digital outputs are also set automatically to the value prior to the power failure.

2.7 Maintenance and Troubleshooting

The robot requires only a minimum of maintenance during operation. It has been designed to make it as easy to service as possible:

- The controller is enclosed, which means that the electronic circuitry is protected when operating in a normal workshop environment.
- Maintenance-free AC motors are used.
- Liquid grease or oil is used for the gear boxes.
- The cabling is routed for longevity, and in the unlikely event of a failure, its modular design makes it easy to change.
- It has a program memory “battery low” alarm.

The robot has several functions to provide efficient diagnostics and error reports:

- It performs a self-test when power on is set.
- Errors are indicated by a message displayed in plain language.
  The message includes the reason for the fault and suggests recovery action.
- A board error is indicated by a LED on the faulty unit.

- Faults and major events are logged and time-stamped. This makes it possible to detect error chains and provides the background for any downtime. The log can be read on the teach pendant display, stored in a file or printed on a printer.
- There are commands and service programs in RAPID to test units and functions.

Most errors detected by the user program can also be reported to and handled by the standard error system. Error messages and recovery procedures are displayed in plain language.

2.8 Robot Motion

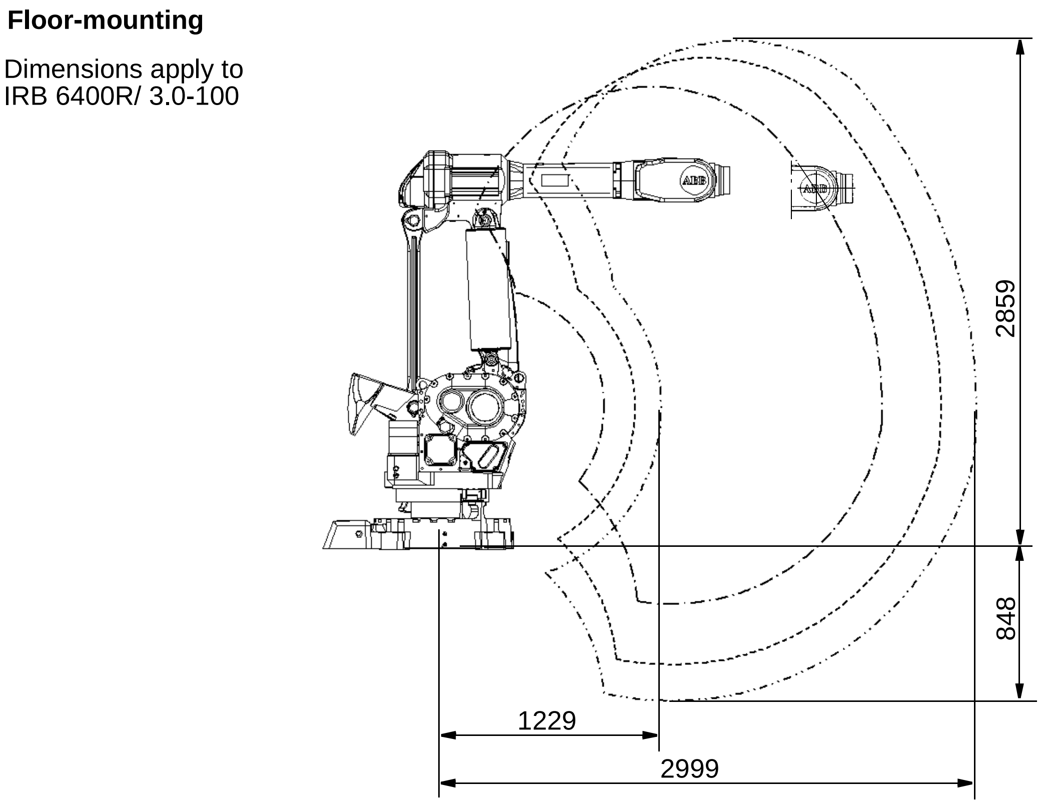


Figure 8 Working space of IRB 6400R (dimensions in mm).

Motion performance

The QuickMove^{TM} concept means that a self-optimizing motion control is used.
The robot automatically optimizes the servo parameters to achieve the best possible performance throughout the cycle - based on load properties, location in working area, velocity and direction of movement.

- No parameters have to be adjusted to achieve correct path, orientation and velocity.
- Maximum acceleration is always obtained (acceleration can be reduced, e.g. when handling fragile parts).
- The number of adjustments that have to be made to achieve the shortest possible cycle time is minimized.

The TrueMove^{TM} concept means that the programmed path is followed – regardless of the speed or operating mode – even after an emergency stop, a safeguarded stop, a process stop, a program stop or a power failure.

The robot can, in a controlled way, pass through singular points, i.e. points where two axes coincide.

Coordinate systems

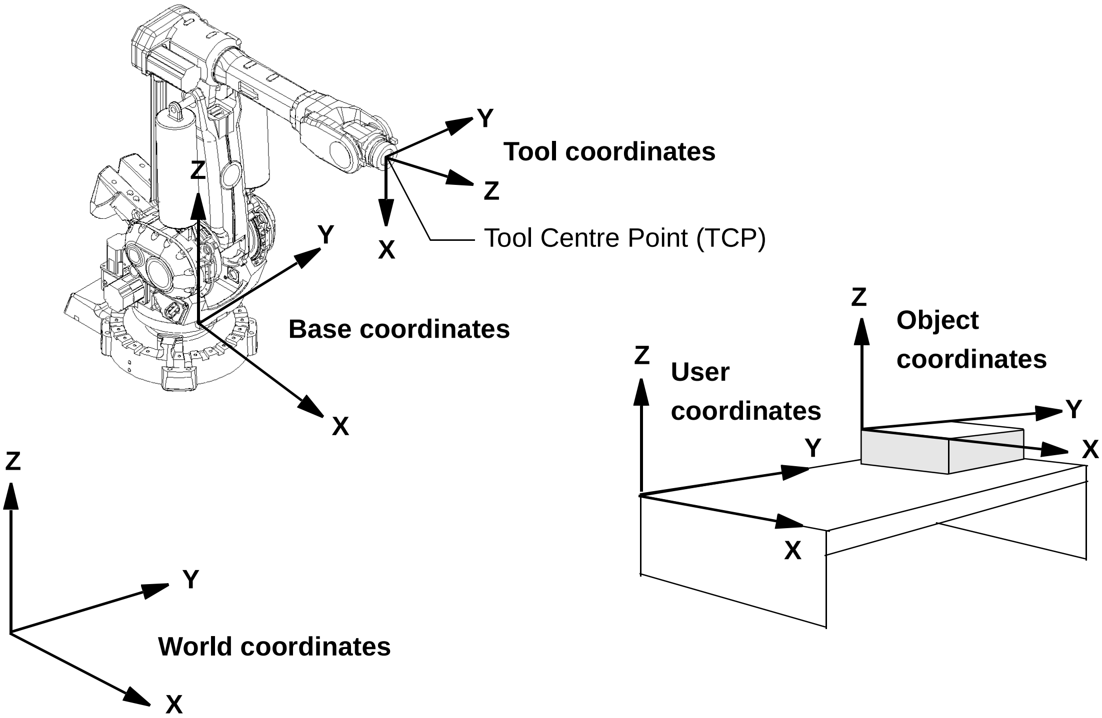


Figure 9 The coordinate systems, used to make jogging and off-line programming easier.

The world coordinate system defines a reference to the floor, which is the starting point for the other coordinate systems. Using this coordinate system, it is possible to relate the robot position to a fixed point in the workshop. The world coordinate system is also very useful when two robots work together or when using a robot carrier.

The base coordinate system is attached to the base mounting surface of the robot.

The tool coordinate system specifies the tool's centre point and orientation.

The user coordinate system specifies the position of a fixture or workpiece manipulator.

The object coordinate system specifies how a workpiece is positioned in a fixture or workpiece manipulator.

The coordinate systems can be programmed by specifying numeric values or jogging the robot through a number of positions (the tool does not have to be removed).

Each position is specified in object coordinates with respect to the tool's position and orientation. This means that even if a tool is changed because it is damaged, the old program can still be used, unchanged, by making a new definition of the tool.
If a fixture or workpiece is moved, only the user or object coordinate system has to be redefined.

Stationary TCP

When the robot is holding a work object and working on a stationary tool, it is possible to define a TCP for that tool. When that tool is active, the programmed path and speed are related to the work object.

Program execution

The robot can move in any of the following ways:

- Joint motion (all axes move individually and reach the programmed position at the same time)
- Linear motion (the TCP moves in a linear path)
- Circle motion (the TCP moves in a circular path)

Soft servo - allowing external forces to cause deviation from programmed position - can be used as an alternative to mechanical compliance in grippers, where imperfection in processed objects can occur.

If the location of a workpiece varies from time to time, the robot can find its position by means of a digital sensor. The robot program can then be modified in order to adjust the motion to the location of the part.

Jogging

The robot can be manually operated in any one of the following ways:

- Axis-by-axis, i.e. one axis at a time
- Linearly, i.e. the TCP moves in a linear path (relative to one of the coordinate systems mentioned above)
- Reoriented around the TCP

It is possible to select the step size for incremental jogging. Incremental jogging can be used to position the robot with high precision, since the robot moves a short distance each time the joystick is moved.

During manual operation, the current position of the robot and the external axes can be displayed on the teach pendant.

2.9 External Axes

The robot can control up to six external axes. These axes are programmed and moved using the teach pendant in the same way as the robot’s axes.

The external axes can be grouped into mechanical units to facilitate, for example, the handling of robot carriers, workpiece manipulators, etc.

The robot motion can be simultaneously coordinated with for example, a one-axis linear robot carrier and a rotational external axis.

A mechanical unit can be activated or deactivated to make it safe when, for example, manually changing a workpiece located on the unit. In order to reduce investment costs, any axes that do not have to be active at the same time, can share the same drive unit.

2.10 Inputs and Outputs

A distributed I/O system is used, which makes it possible to mount the I/O units either inside the cabinet or outside the cabinet with a cable connecting the I/O unit to the cabinet.

A number of different input and output units can be installed:

- Digital inputs and outputs.
- Analog inputs and outputs.
- Remote I/O for Allen-Bradley PLC.
- Interbus-S Slave.
- Profibus DP Slave.

The inputs and outputs can be configured to suit your installation:

- Each signal and unit can be given a name, e.g. gripper, feeder.
- I/O mapping (i.e. a physical connection for each signal).
- Polarity (active high or low).
- Cross connections.
- Up to 16 digital signals can be grouped together and used as if they were a single signal when, for example, entering a bar code.

Signals can be assigned to special system functions, such as program start, so as to be able to control the robot from an external panel or PLC.

The robot can work as a PLC by monitoring and controlling I/O signals:

- I/O instructions can be executed concurrent to the robot motion.
- Inputs can be connected to trap routines. (When such an input is set, the trap routine starts executing. Following this, normal program execution resumes. In most cases, this will not have any visible effect on the robot motion, i.e. if a limited number of instructions are executed in the trap routine.)
- Background programs (for monitoring signals, for example) can be run in parallel with the actual robot program. Requires Multitasking option, see Product Specification RobotWare.

Manual functions are available to:

- List all the signal values.
- Create your own list of your most important signals.
- Manually change the status of an output signal.
- Print signal information on a printer.

I/O signals can also be routed parallel or serial to connectors on the upper arm of the robot.

2.11 Communication

The robot can communicate with computers or other equipment via RS232/RS422 serial channels or via Ethernet. However this requires optional software, see Product Specification RobotWare.

2.12 Spotweld Harness (option)

The robot can be supplied with an integrated spot welding harness as well as a mechanical support for externally mounted process solutions.

The integrated spotwelding harness is used to supply primary current and cooling water to the upper arm. Connections at the manipulator base and the upper arm housing. For more information, see section 3.12 on page 48 and Figure 31 and Figure 32.

3 Technical specification

Applies to standard and Foundry versions unless otherwise stated.

3.1 Structure

Weight:	Manipulator	IRB 6400R /2.5-120	2060 kg
		IRB 6400R /2.5-150	2060 kg
		IRB 6400R /2.5-200	2230 kg
		IRB 6400R /2.8-150	2240 kg
		IRB 6400R /2.8-200	2390 kg
		IRB 6400R /3.0-100	2250 kg
	Controller		240 kg
Volume:	Controller	950 x 800 x 540 mm	

Airborne noise level:

The sound pressure level outside the working space	< 70 dB (A) Leq (acc. to Machinery directive 98/37/EEC)

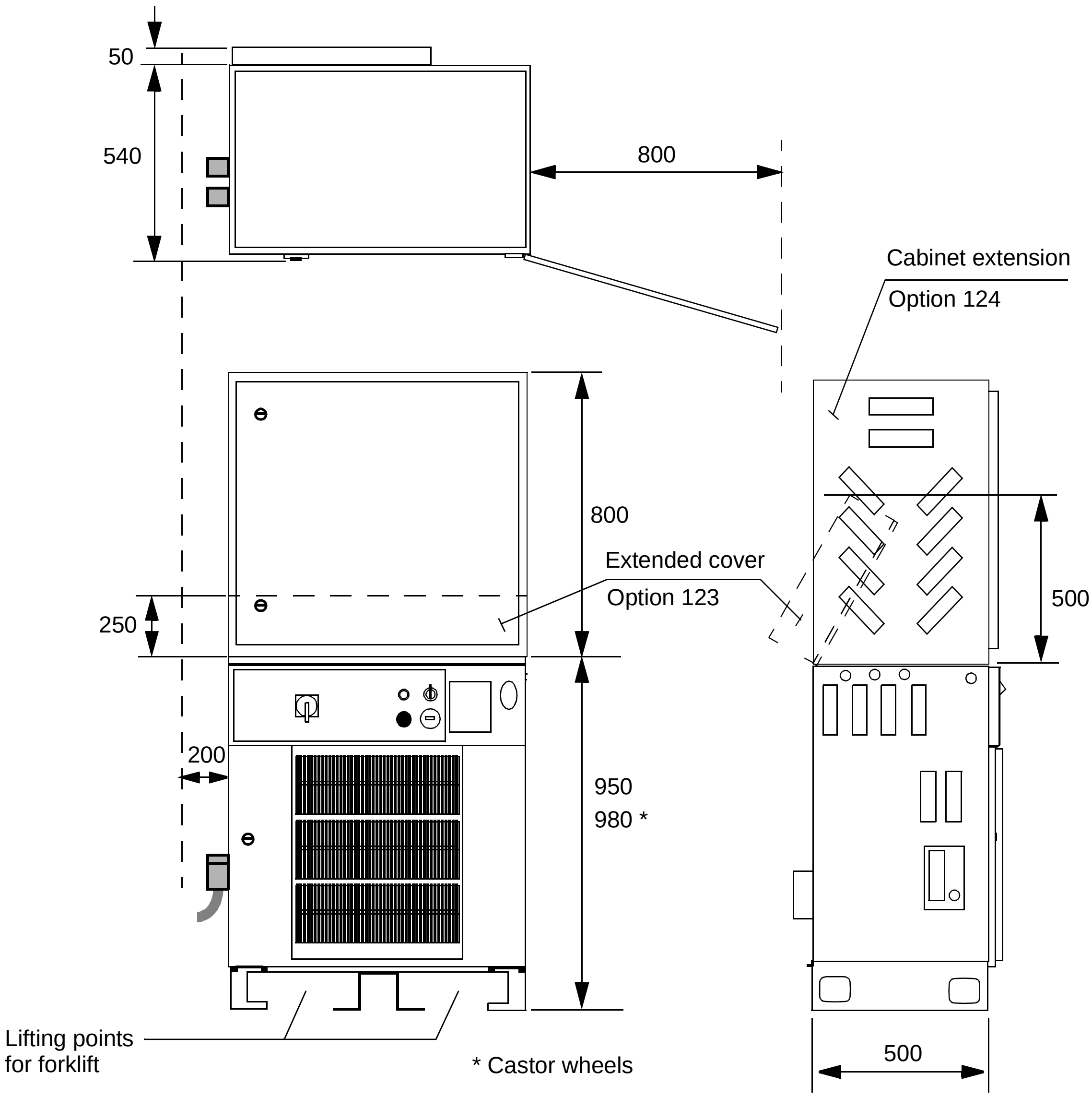
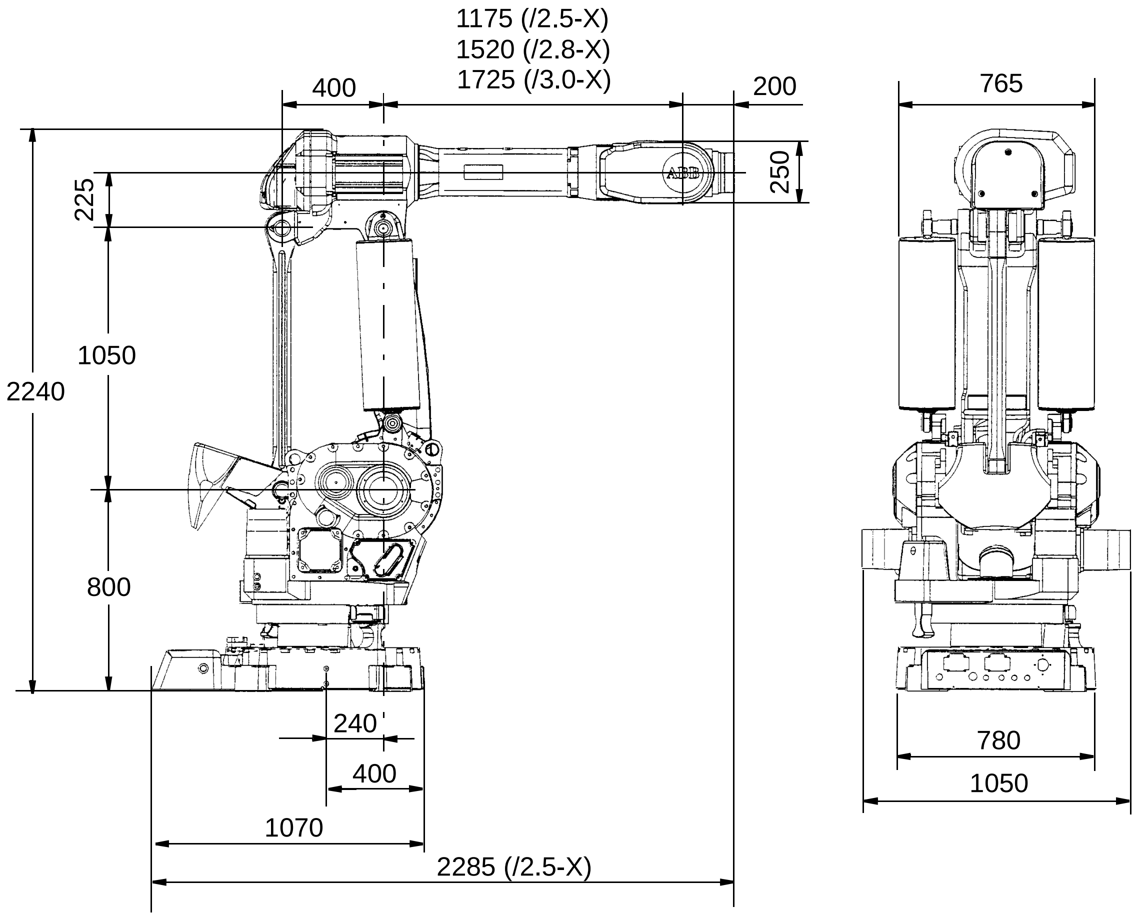
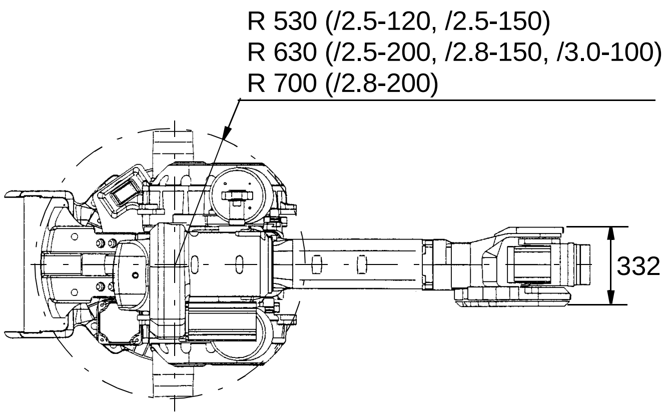


Figure 10 View of the controller from the front, from above and from the side (dimensions in mm).

IRB 6400R /2.5-120, /2.5-150, /2.5-200, /2.8-150, /2.8-200 and /3.0-100





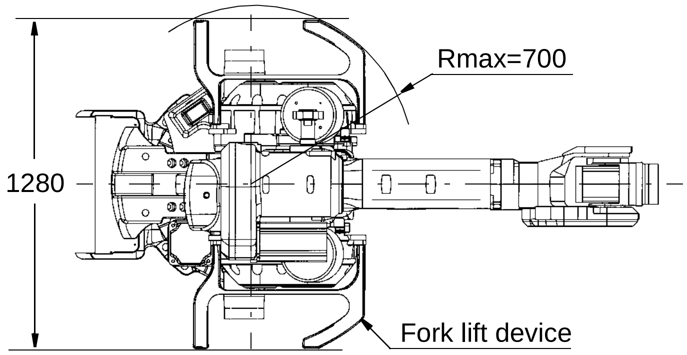


Figure 11 View of the manipulator from the side, rear and above (dimensions in mm).

3.2 Safety/Standards

The robot conforms to the following standards:

EN 292-1	Safety of machinery, terminology
EN 292-2	Safety of machinery, technical specifications
EN 954-1	Safety of machinery, safety related parts of control systems
EN 60204[1]	Electrical equipment of industrial machines
IEC 204-1	Electrical equipment of industrial machines
ISO 10218, EN 775	Manipulating industrial robots, safety
ANSI/RIA 15.06/1992	Industrial robots, safety requirements
ISO 9409-1	Manipulating industrial robots, mechanical interface
ISO 9787	Manipulating industrial robots, coordinate systems and motions
IEC 529	Degrees of protection provided by enclosures
EN 50081-2	EMC, Generic emission
EN 50082-2	EMC, Generic immunity
ANSI/UL 1740-1996 (option)	Standard for Industrial Robots and Robotic Equipment
CAN/CSA Z 434-94 (option)	Industrial Robots and Robot Systems - General Safety Requirements

Safeguarded space stops via inputs

External safety equipment can be connected to the robot's two-channel emergency stop chain in several different ways (see Figure 12).

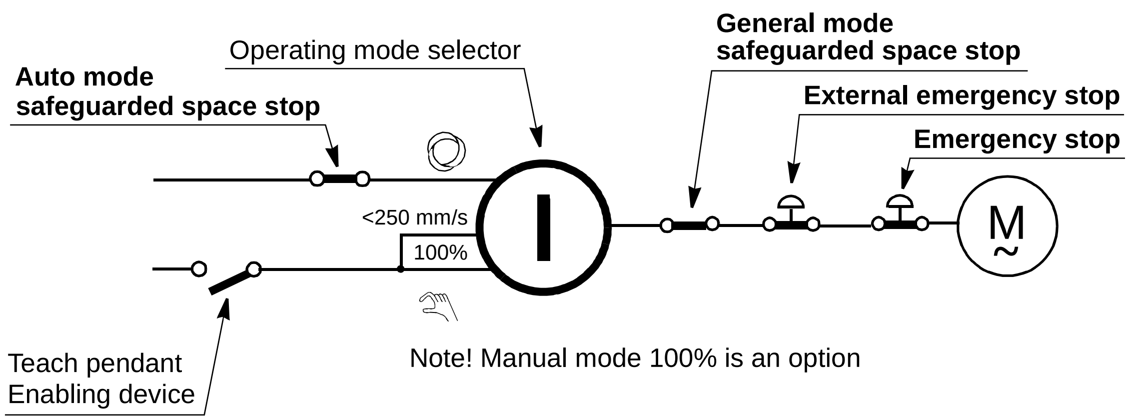


Figure 12 All safeguarded space stops force the robot's motors to the MOTORS OFF state. A time delay can be used on the emergency stops or any safeguarded space stops.

1. There is a deviation from the extra demand for only electromechanical components on emergency stop of category 0 in paragraph 9.2.5.4. EN 60204-1 accepts one channel circuit without monitoring, instead the design is made to comply with category 3 according to EN 954-1, where the demand for redundancy is founded.

3.3 Operation

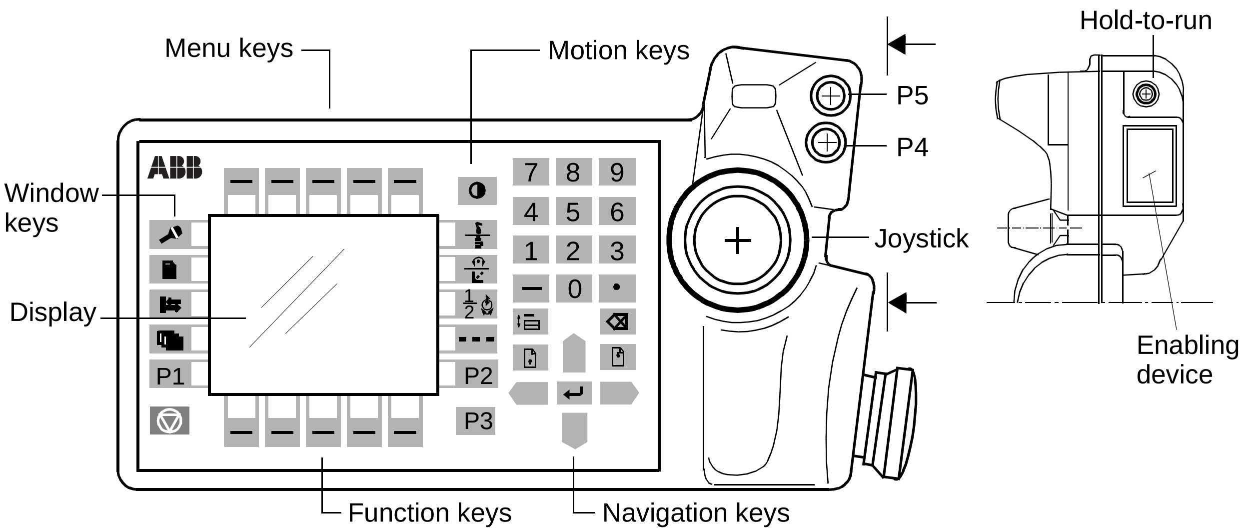


Figure 13 The teach pendant is very easy to use since any functions provided via the function and menu keys are described in plain language. The remaining keys can perform only one function each.

Display
16 text lines with 40 characters per line.

Motion keys
Select the type of movement when jogging.

Navigation keys
Move the cursor and enter data.

Menu keys
Display pull-down menus.

Function keys
Select the commands used most often.

Window keys
Display one of the robot's various windows. These windows control a number of different functions:

- Jog (manual operation)
- Program, edit and test a program
- Manual input/output management
- File management
- System configuration
- Service and troubleshooting
- Automatic operation

User-defined keys (P1-P5)
Five user-defined keys that can be configured to set or reset an output (e.g. open/close gripper) or to activate a system input (see chapter 3.10).

3.4 Installation

Operating requirements

Protection standards		IEC529
Standard	Manipulator	IP54
	Wrist	IP55
	Controller	IP54

Explosive environments
The robot must not be located or operated in an explosive environment.

Ambient temperature

Manipulator during operation	+5^{o}C (41^{o}F) to +50^{o}C (122^{o}F)
Controller during operation	+5^{o}C (41^{o}F) to +52^{o}C (125^{o}F)
Complete robot during transportation and storage,	-25^{o}C (13^{o}F) to +55^{o}C (131^{o}F)
for short periods (not exceeding 24 hours)	up to +70^{o}C (158^{o}F)

Relative humidity

Complete robot during transportation and storage	Max. 95% at constant temperature
Complete robot during operation	Max. 95% at constant temperature

Power supply

Mains voltage	200-600 V, 3p (3p + N for certain options, +10%,-15%
Mains frequency	48.5 to 61.8 Hz
Rated power:	
IRB 6400R	7.8 kVA (transformer size)
External axes drives in separate cabinet	7.2 kVA (transformer size)
Absolute measurement backup	1000 h (rechargeable battery)

Configuration

The robot is very flexible and can, by using the teach pendant, easily be configured to suit the needs of each user:

Authorisation	Password protection for configuration and program window
Most common I/O	User-defined lists of I/O signals
Instruction pick list	User-defined set of instructions
Instruction builder	User-defined instructions
Operator dialogs	Customised operator dialogs
Language	All text on the teach pendant can be displayed in several languages
Date and time	Calendar support
Power on sequence	Action taken when the power is switched on
EM stop sequence	Action taken at an emergency stop
Main start sequence	Action taken when the program is starting from the beginning
Program start sequence	Action taken at program start

Program stop sequence	Action taken at program stop
Change program sequence	Action taken when a new program is loaded
Working space	Working space limitations
External axes	Number, type, common drive unit, mechanical units
Brake delay time	Time before brakes are engaged
I/O signal	Logical names of boards and signals, I/O mapping, cross connections, polarity, scaling, default value at start up, interrupts, group I/O
Serial communication	Configuration

For a detailed description of the installation procedure, see the Product Manual - Installation and Commissioning.

Mounting the manipulator

Maximum load in relation to the base coordinate system.

	Endurance load in operation	**Max. load at emergency stop**
Force xy	±14000 N	±38000 N
Force z	22000 ±8000 N	22000 ±19000 N
Torque xy	±34000 Nm	±61000 Nm
Torque z	7000 Nm	±15000 Nm

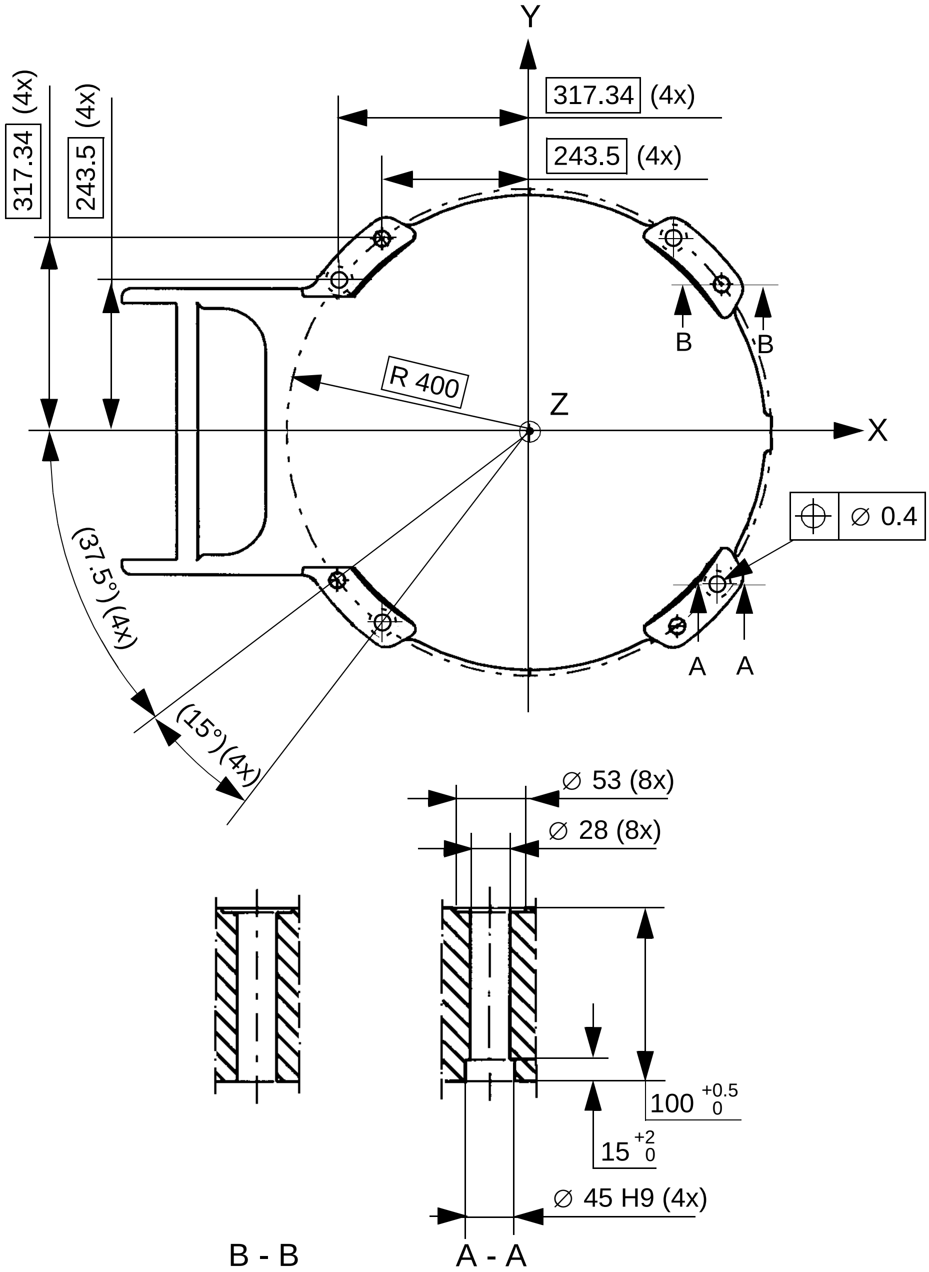
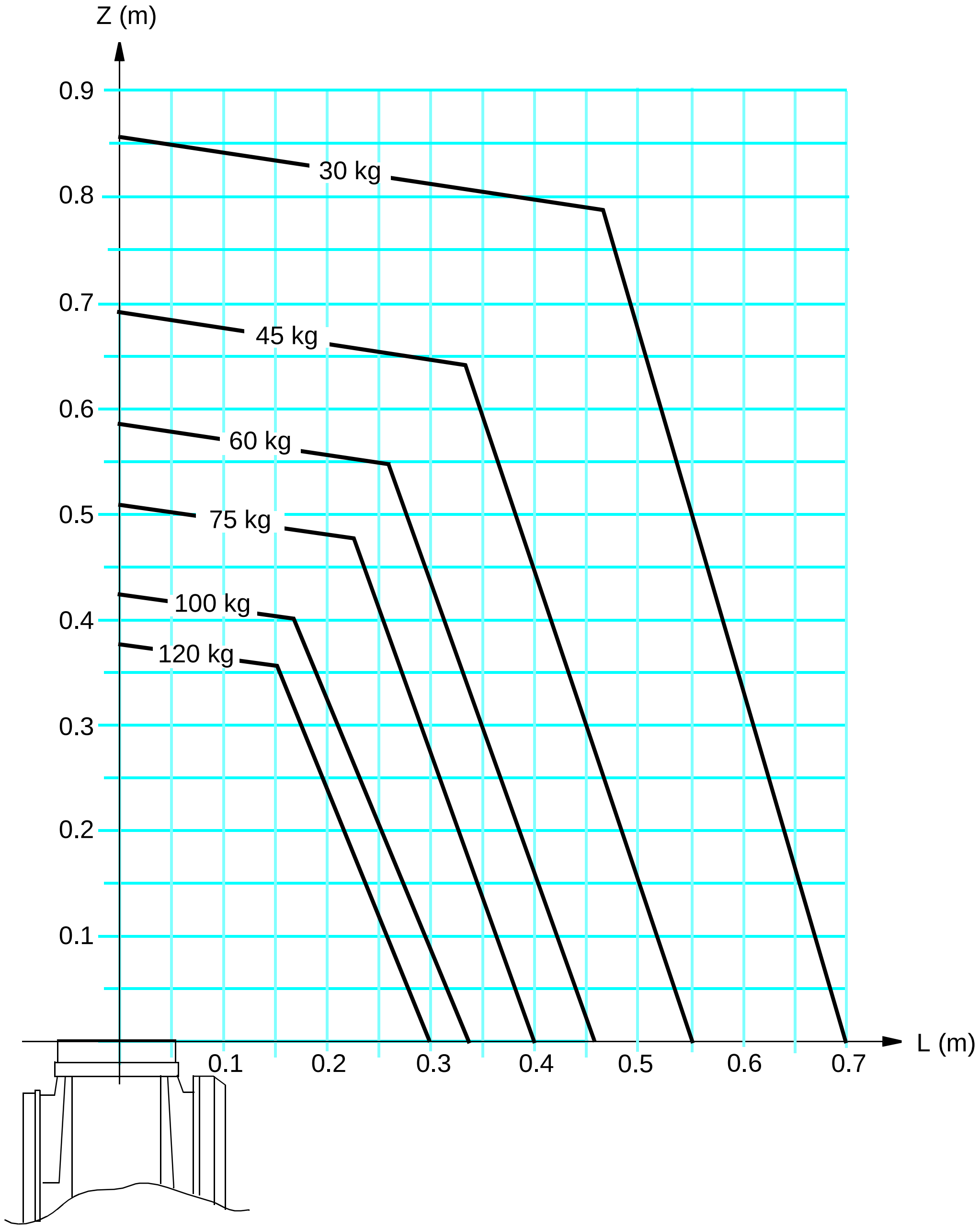


Figure 14 Hole configuration (dimensions in mm).

Load diagrams

Load diagram for **IRB 6400R /2.5-120 and /3.0-100**

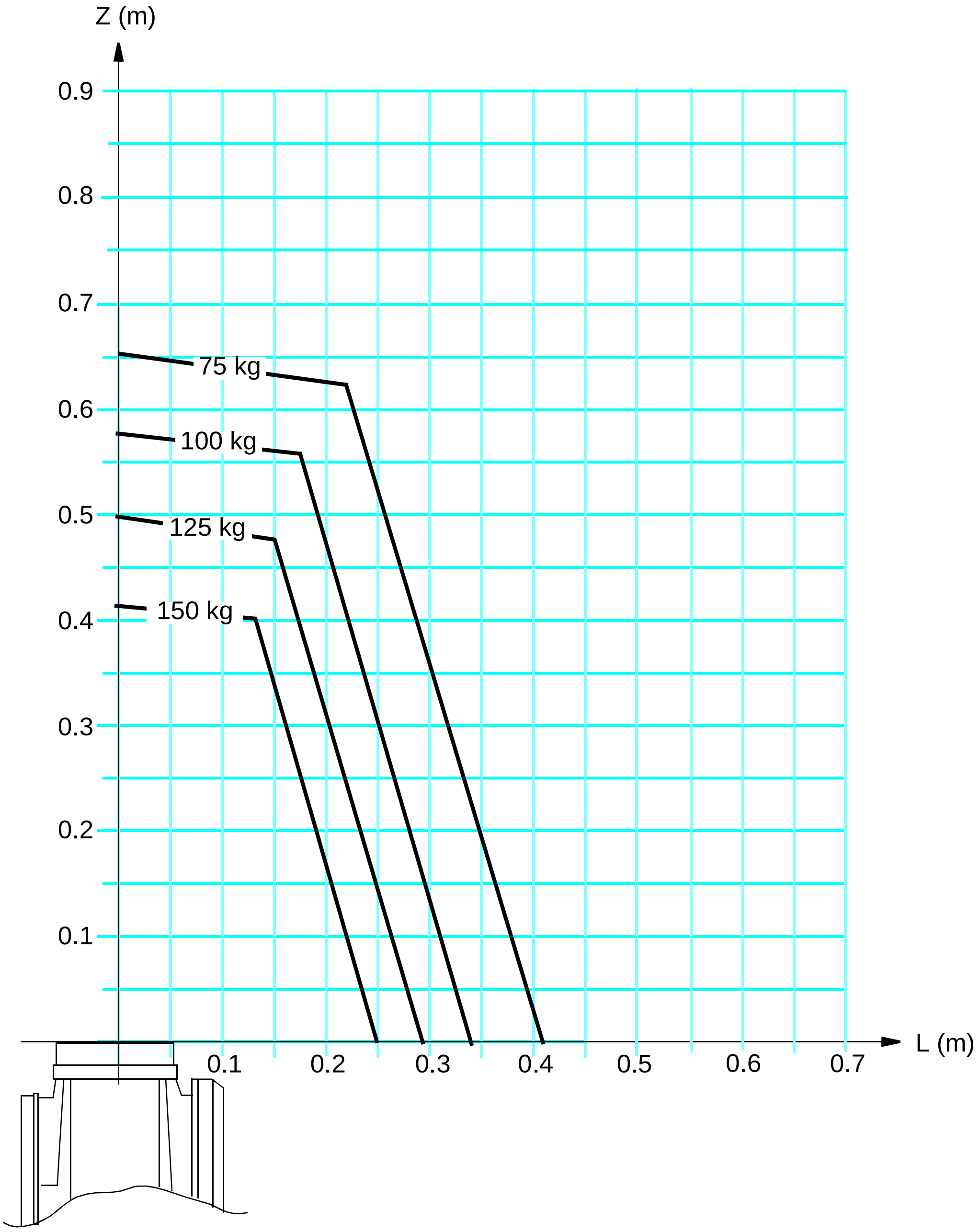
(The curve for 120 kg is not valid for /3.0-100, max. handling capacity limited to 100 kg).



The load diagram is valid for J_0 <100 kgm^2.
J_0 = the maximum component (J_{X0}, J_{Y0}, J_{Z0}) of the moment of inertia of the handling weight at its centre of gravity.

Figure 15 Maximum weight permitted for load mounted on the mounting flange at different positions (centre of gravity).

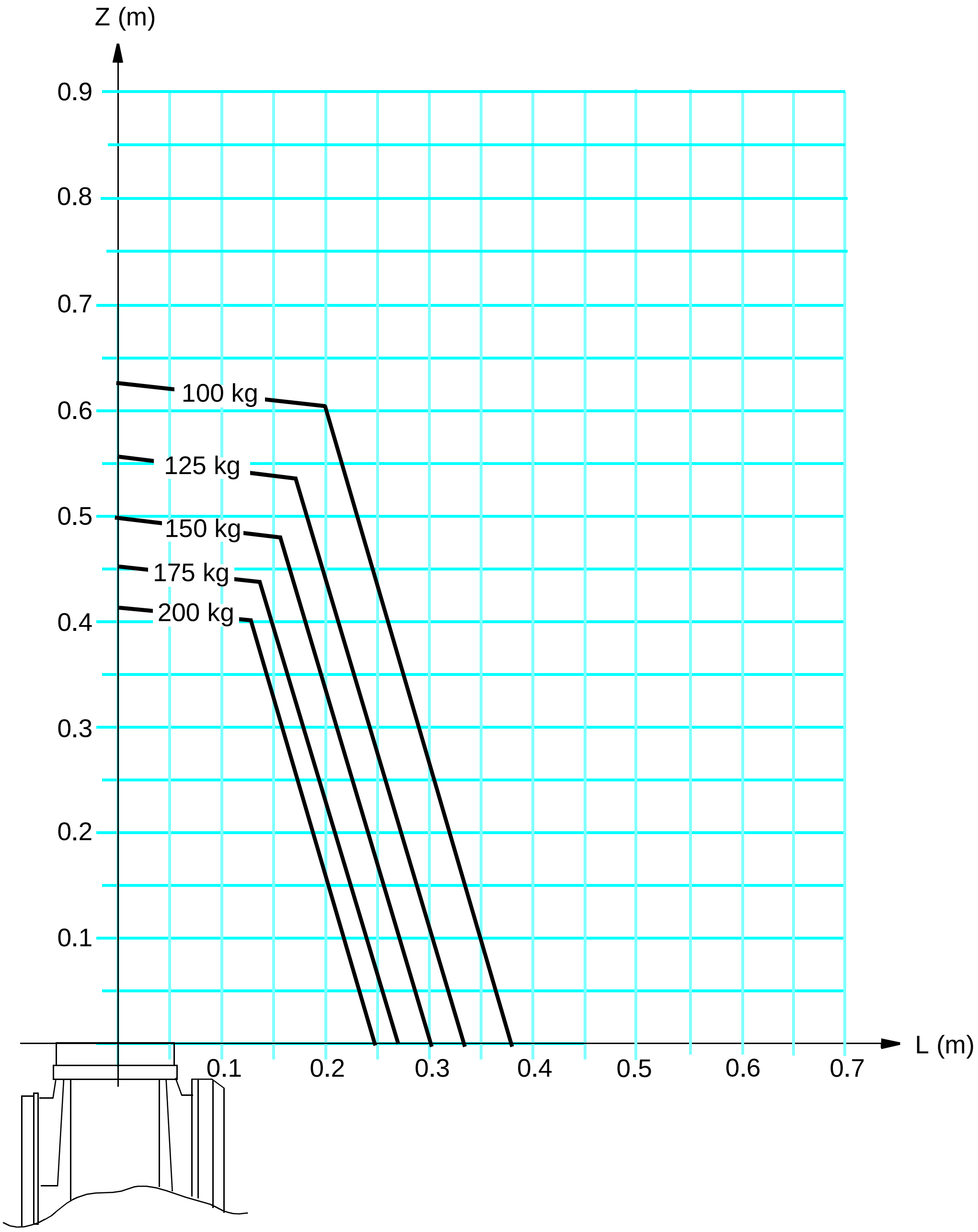
Load diagram for **IRB 6400R /2.5-150 and /2.8-150**



The load diagram is valid for J_0 <100 kgm^2.
J_0 = the maximum component (J_{X0}, J_{Y0}, J_{Z0}) of the moment of inertia of the handling weight at its centre of gravity.

Figure 16 Maximum weight permitted for load mounted on the mounting flange at different positions (centre of gravity).

Load diagram for **IRB 6400R /2.5-200 and /2.8-200**



The load diagram is valid for J_0 <100 kgm^2.
J_0 = the maximum component (J_{X0}, J_{Y0}, J_{Z0}) of the moment of inertia of the handling weight at its centre of gravity.

Figure 17 Maximum weight permitted for load mounted on the mounting flange at different positions (centre of gravity).

Handling capacity for IRB 6400R /2.8-150 in press-tending application

Note! Option 090, Cooling for axis 1 motor, must be installed.

The weight and dimensions of the part and gripper are limited by the maximum static torque and moment of inertia.

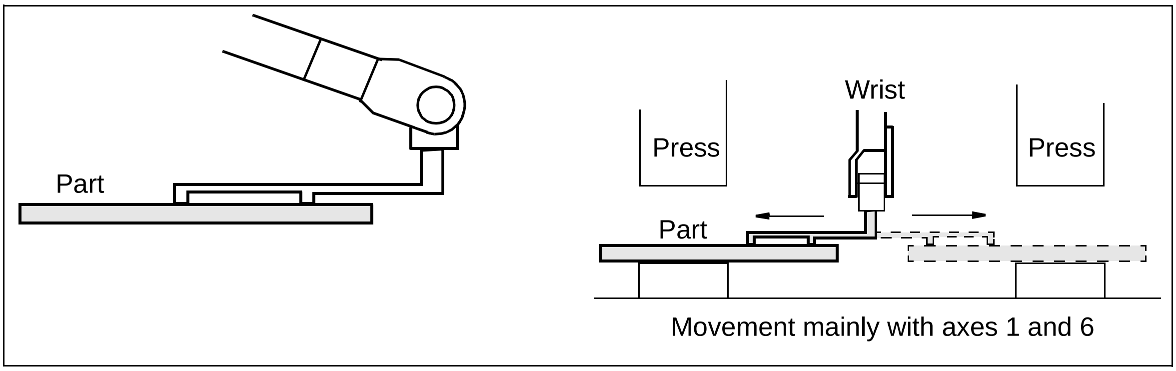


Figure 18 A-movement (inward movement).

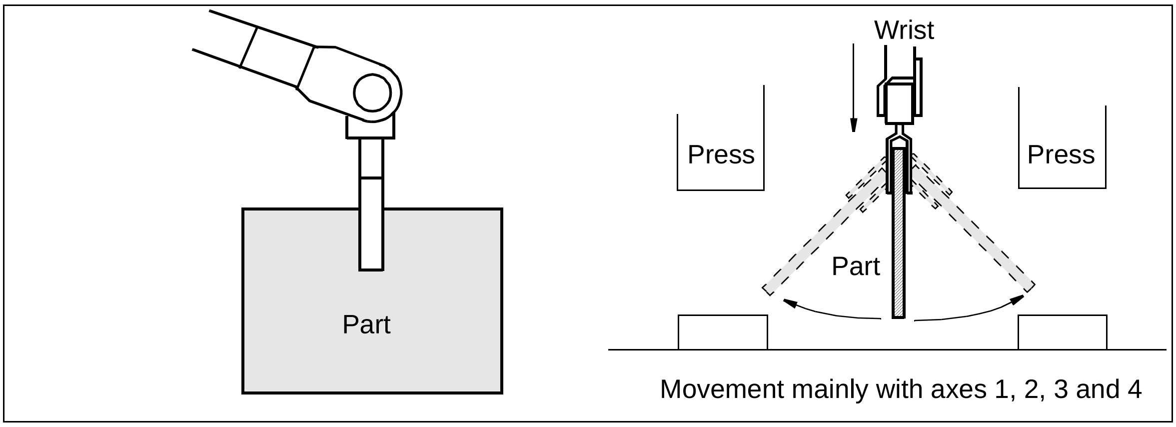


Figure 19 B-movement.

Static torque:	A-movement	Axis 5 $Ma_5 < 650$ Nm
	B-movement	Axis 4 $Mb_4 < 650$ Nm
Moment of inertia:	A-movement	Axis 5, $Ja_5 < 105$ kgm^2
		Axis 6, $Ja_6 < 120$ kgm^2
	B-movement	Axis 4, $Jb_4 < 105$ kgm^2
		Axis 5, $Jb_5 < 120$ kgm^2

Approximations of M and J can be calculated using the following formula:

$Ma_5 = 9.81 \bullet (m_g \bullet r + m_p \bullet s)$ (Nm)

$Mb_4 = 9.81 \bullet (m_g \bullet (r + 0.2) + m_p \bullet (s + 0.2))$ (Nm)

$Ja_5 = m_g / 12 \bullet c^2 + m_g \bullet r^2 + m_p / 12 \bullet a^2 + m_p \bullet s^2$ (kgm^2)

$Ja_6 = m_g / 12 \bullet c^2 + m_g \bullet r^2 + m_p / 12 \bullet (a^2 + b^2) + m_p \bullet s^2$ (kgm^2)

$Jb_4 = m_g / 12 \bullet c^2 + m_g \bullet (r + 0.2)^2 + m_p / 12 \bullet a^2 + m_p \bullet (s + 0.2)^2$ (kgm^2)

$Jb_5 = m_g / 12 \bullet c^2 + m_g \bullet (r + 0.2)^2 + m_p / 12 \bullet (a^2 + b^2) + m_p \bullet (s + 0.2)^2$ (kgm^2)

m_g = weight of gripper (kg) m_p = weight of part (kg)

Distances a, b, c, r and s (m) are shown in Figure 20.

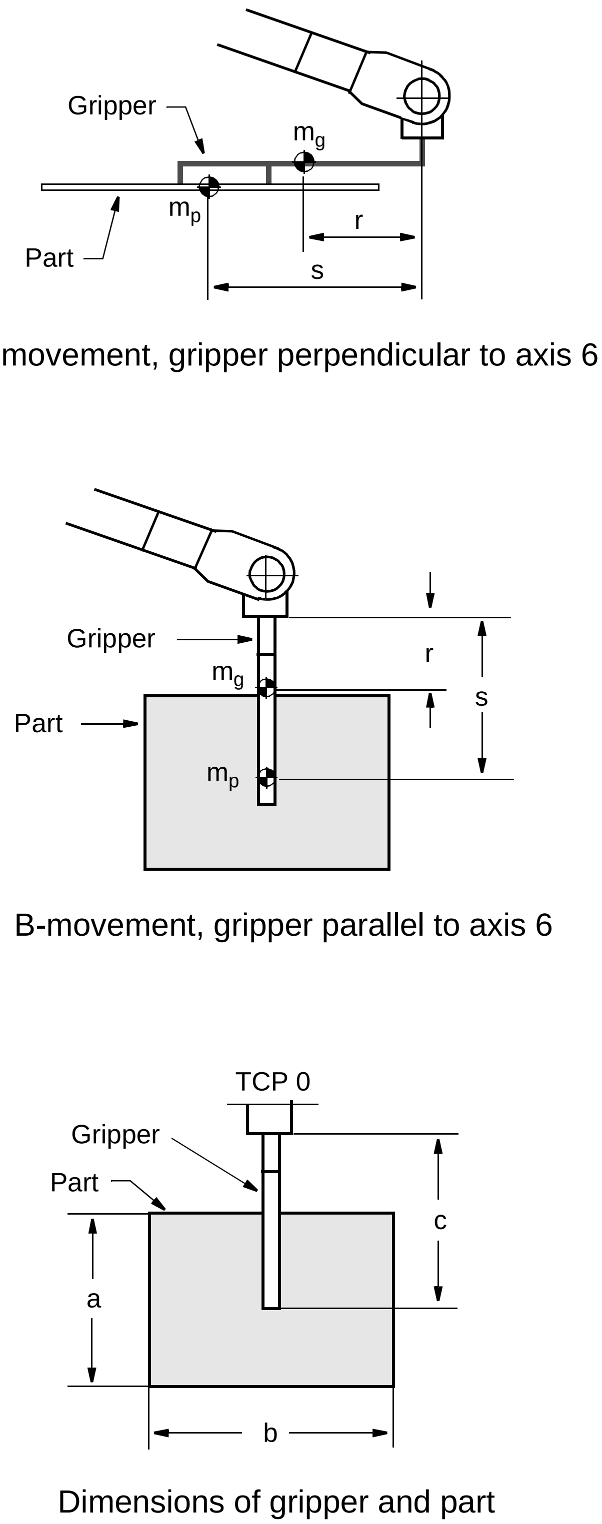


Figure 20 Distances r and s (m).

Mounting equipment

Extra loads can be mounted on the upper arm and the frame. Definitions of distances and masses are shown in Figure 21 and Figure 22.
The robot is supplied with holes for mounting extra equipment (see Figure 23).

Upper arm - Balancing unit type A

IRB 6400R /2.5-120, /2.5-150, /2.5-200, /2.8-150 and /2.8-200

Permitted extra load on upper arm plus the maximum handling weight (See Figure 21):
M1 ≤50 kg with distance a ≤500 mm, centre of gravity in axis 3 extension
or
M2 ≤50 kg with distance b ≤400 mm
or
M3 ≤15 kg with distance c ≥300 mm
If the handling weight is lower than the maximum weight, M1 alt. M2 can be increased as follows:
(M1 alt. M2 + handling weight) ≤ (50 kg + max. handling weight).

For example, if the handling weight for 2.5-150 is only 120 kg, M2 can be 80 kg.

IRB 6400R /3.0-100

Permitted extra load on upper arm (See Figure 21):
M1 ≤50 kg with distance a ≤500 mm, centre of gravity in axis 3 extension
or
M2 ≤20 kg with distance b ≤400 mm
or
M3 ≤5 kg with distance c ≥300 mm

Upper arm - Balancing unit type B

IRB 6400R /2.5-120, /2.5-150, /2.5-200 and /2.8-150

Permitted extra load on upper arm plus the maximum handling weight (See Figure 21):
M1 ≤70-155 kg with distance a ≤ 500 mm, centre of gravity in axis 3 extension, see Note 1.
or
M2 ≤50 kg with distance b ≤400 mm, see Note 1.
or
M3 ≤15 kg with distance c ≥300 mm, see Note 1.
If the handling weight is lower than the maximum weight, M1 alt. M2 can be increased as follows:
(M1 + handling weight) ≤ (155 kg + max. handling weight).
(M2 + handling weight) ≤ (50 kg + max. handling weight).

For example, if the handling weight for 2.5-150 is only 120 kg, M2 can be 80 kg.

Note 1. Handling weight + extra load on upper arm must always be >70kg

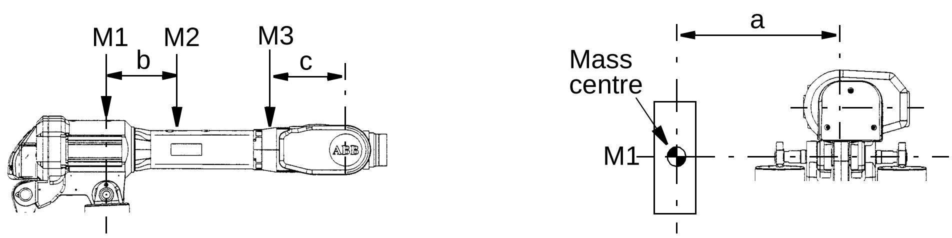


Figure 21 Permitted extra load on upper arm.

Frame (Hip Load)

Permitted extra load on frame is $J_H = 120$ kgm^2.
Recommended position (see Figure 22).
$J_H = J_{H0} + M4 \cdot R^2$

where	J_{H0}	is the moment of inertia of the equipment
	R	is the radius (m) from the centre of axis 1
	M4	is the total mass (kg) of the equipment including bracket and harness (≤320 kg)

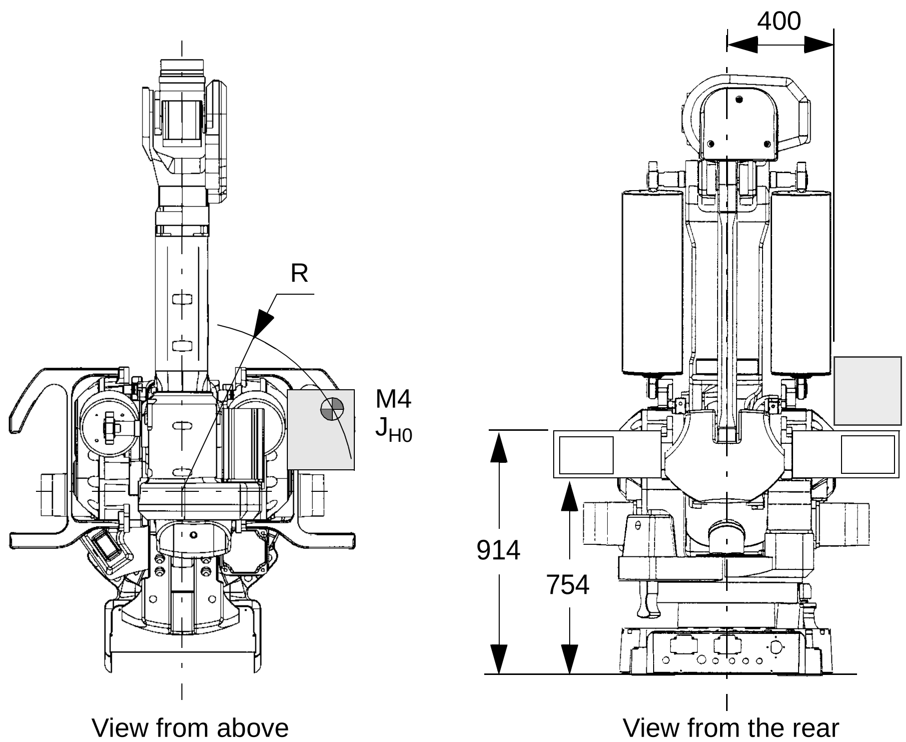


Figure 22 Extra load on frame of IRB 6400R (dimensions in mm).

Mounting of hip load

The extra load can be mounted either on the fork lift device or on the frame. Holes for mounting see Figure 24.

When mounting on the frame all the six holes (2x3, ∅18) on one side must be used.

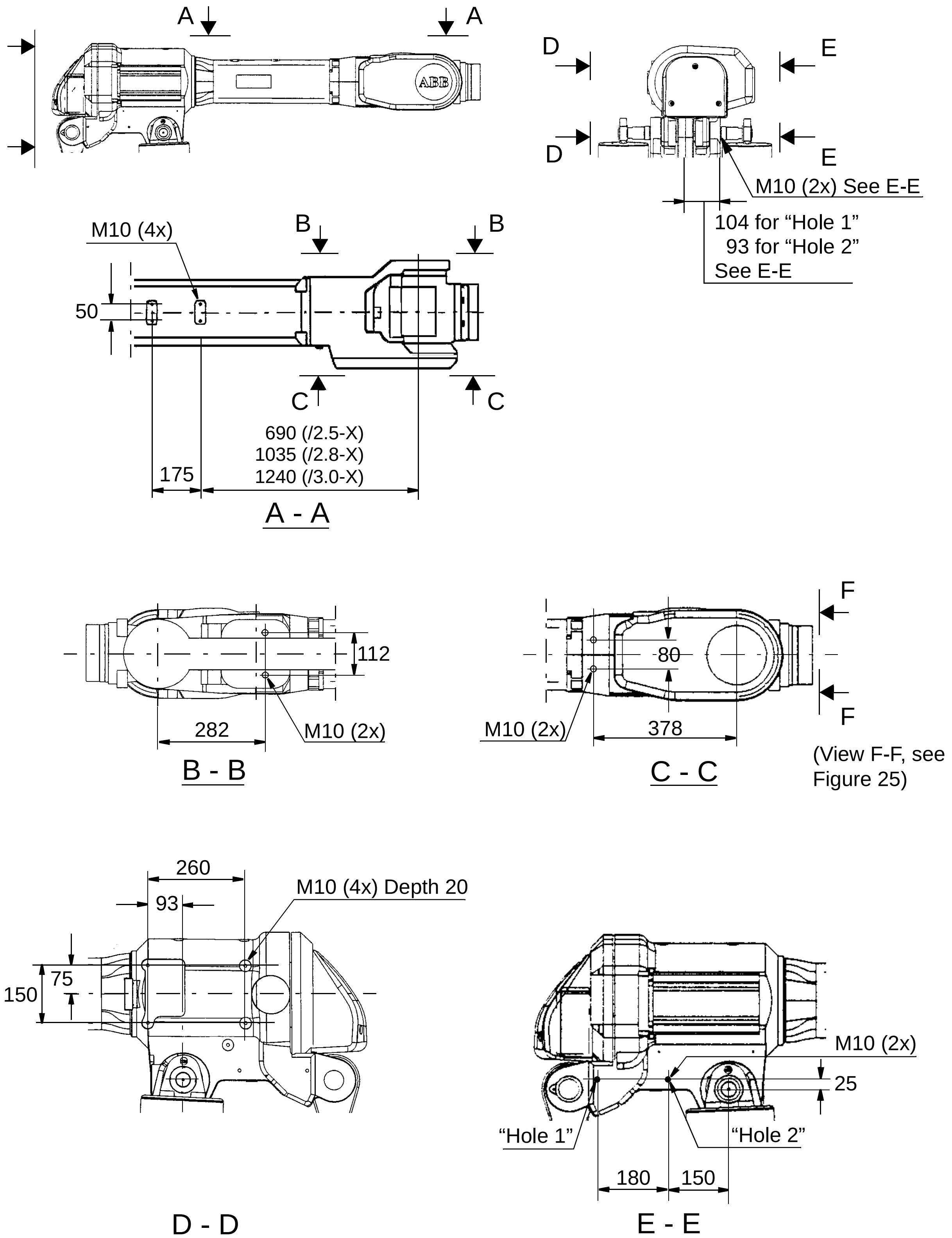


Figure 23 Holes for mounting extra equipment on the upper arm (dimensions in mm).

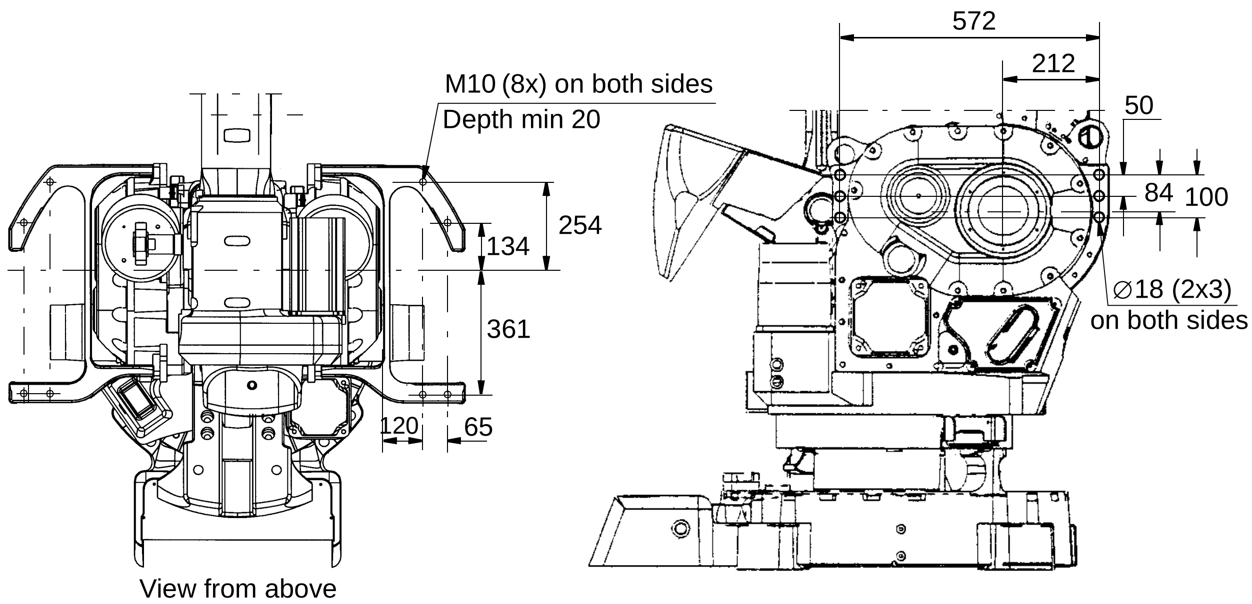


Figure 24 Holes for mounting of extra load on the fork lift device and the frame (dimensions in mm).

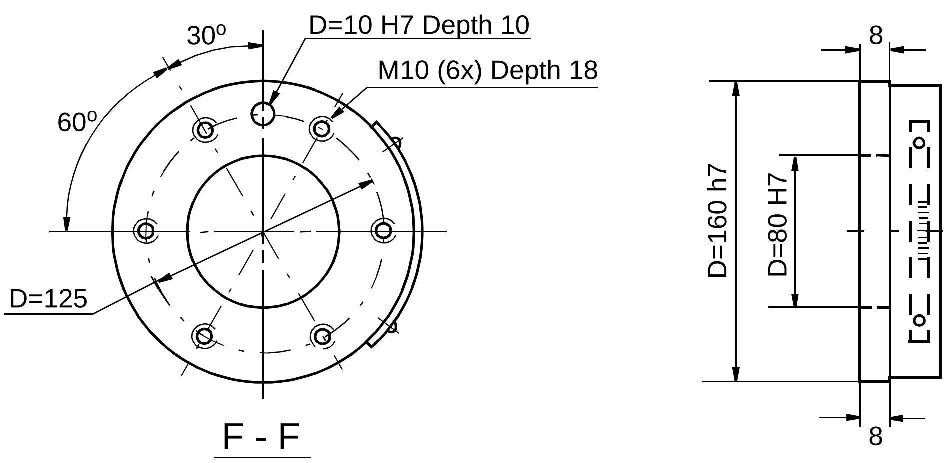


Figure 25 The mechanical interface (mounting flange) ISO 9409-1-A125 (dimensions in mm).

As an option there is an electrically insulated tool flange.
For more information see page 54 and Figure 35.

3.5 Programming

The programming language - RAPID - is a high-level application-oriented programming language and includes the following functionality:

- hierarchial and modular structure
- functions and procedures
- global or local data and routines
- data typing, including structured and array types
- user defined names on variables, routines, inputs/outputs etc.
- extensive program flow control
- arithmetic and logical expressions
- interrupt handling
- error handling
- user defined instructions
- backward execution handler

The available sets of instructions/functions are given below. A subset of instructions to suit the needs of a particular installation, or the experience of the programmer, can be installed in pick lists. New instructions can easily be made by defining macros consisting of a sequence of standard instructions.

Note that the lists below only cover BaseWare OS. For instructions and functions associated with optional software, see Product Specification RobotWare.

Miscellaneous

:=	Assigns a value
WaitTime	Waits a given amount of time
WaitUntil	Waits until a condition is met
comment	Inserts comments into the program
OpMode	Reads the current operating mode
RunMode	Reads the current program execution mode
Dim	Gets the size of an array
Present	Tests if an optional parameter is used
Load	Loads a program module during execution
UnLoad	Deletes a program module during execution

To control the program flow

ProcCall	Calls a new procedure
CallByVar	Calls a procedure by a variable
RETURN	Finishes execution of a routine
FOR	Repeats a given number of times
GOTO	Goes to (jumps to) a new instruction
Compact IF	IF a condition is met, THEN execute one instruction
IF	IF a condition is met, THEN execute a sequence of instructions
label	Line name (used together with GOTO)
TEST	Depending on the value of an expression ...

WHILE	Repeats as long as ...
Stop	Stops execution
EXIT	Stops execution when a restart is not allowed
Break	Stops execution temporarily

Motion settings

AccSet	Reduces the acceleration
ConfJ	Controls the robot configuration during joint movement
ConfL	Monitors the robot configuration during linear movement
VelSet	Changes the programmed velocity
GripLoad	Defines the payload
SingArea	Defines the interpolation method used through singular points
PDispOn	Activates program displacement
PDispSet	Activates program displacement by specifying a value
DefFrame	Defines a program displacement automatically
DefDFrame	Defines a displacement frame
EOffsOn	Activates an offset for an external axis
EOffsSet	Activates an offset for an external axis using a value
ORobT	Removes a program displacement from a position
SoftAct	Activates soft servo for a robot axis
TuneServo	Tunes the servo

Motion

MoveC	Moves the TCP circularly
MoveJ	Moves the robot by joint movement
MoveL	Moves the TCP linearly
MoveAbsJ	Moves the robot to an absolute joint position
MoveXDO	Moves the robot and set an output in the end position
SearchC	Searches during circular movement
SearchL	Searches during linear movement
ActUnit	Activates an external mechanical unit
DeactUnit	Deactivates an external mechanical unit
Offs	Displaces a position
RelTool	Displaces a position expressed in the tool coordinate system
MirPos	Mirrors a position
CRobT	Reads current robot position (the complete *robtarget*)
CJointT	Reads the current joint angles
CPos	Reads the current position (*pos* data)
CTool	Reads the current tool data
CWObj	Reads the current work object data
StopMove	Stops robot motion
StartMove	Restarts robot motion

Input and output signals

InvertDO	Inverts the value of a digital output signal
PulseDO	Generates a pulse on a digital output signal
Reset	Sets a digital output signal to 0
Set	Sets a digital output signal to 1
SetAO	Sets the value of an analog output signal
SetDO	Sets the value of a digital output signal after a defined time
SetGO	Sets the value of a group of digital output signals
WaitDI	Waits until a digital input is set
WaitDO	Waits until a digital output is set
AInput	Reads the value of an analog input signal

DInput	Reads the value of a digital input signal
DOutput	Reads the value of a digital output signal
GInput	Reads the value of a group of digital input signals
GOutput	Reads the value of a group of digital output signals
TestDI	Tests if a digital input signal is set
IODisable	Disables an I/O module
IOEnable	Enables an I/O module

Interrupts

ISignalDI	Orders interrupts from a digital input signal
ISignalDO	Orders interrupts from a digital output signal
ITimer	Orders a timed interrupt
IDelete	Cancels an interrupt
ISleep	Deactivates an interrupt
IWatch	Activates an interrupt
IDisable	Disables interrupts
IEnable	Enables interrupts
CONNECT	Connects an interrupt to a trap routine

Error Recovery

EXIT	Terminates program execution
RAISE	Calls an error handler
RETRY	Restarts following an error
TRYNEXT	Skips the instruction that has caused the error
RETURN	Returns to the routine that called the current routine

Communication

TPErase	Erases text printed on the teach pendant
TPWrite	Writes on the teach pendant
TPReadFK	Reads function keys
TPReadNum	Reads a number from the teach pendant
ErrWrite	Stores an error message in the error log

System & Time

ClkReset	Resets a clock used for timing
ClkStart	Starts a clock used for timing
ClkStop	Stops a clock used for timing
ClkRead	Reads a clock used for timing
CDate	Reads the current date as a string
CTime	Reads the current time as a string
GetTime	Gets the current time as a numeric value

Mathematics

Add	Adds a numeric value
Clear	Clears the value
Decr	Decrements by 1
Incr	Increments by 1
Abs	Calculates the absolute value
Sqrt	Calculates the square root
Exp	Calculates the exponential value with the base “e”
Pow	Calculates the exponential value with an arbitrary base
ACos	Calculates the arc cosine value
ASin	Calculates the arc sine value
ATan/ATan2	Calculates the arc tangent value

Cos	Calculates the cosine value
Sin	Calculates the sine value
Tan	Calculates the tangent value
EulerZYX	Calculates Euler angles from an orientation
OrientZYX	Calculates the orientation from Euler angles
PoseInv	Inverts a pose
PoseMult	Multiplies a pose
PoseVect	Multiplies a pose and a vector
Round	Rounds a numeric value
Trunc	Truncates a numeric value

Text strings

NumToStr	Converts numeric value to string
StrFind	Searches for a character in a string
StrLen	Gets the string length
StrMap	Maps a string
StrMatch	Searches for a pattern in a string
StrMemb	Checks if a character is a member of a set
StrOrder	Checks if strings are ordered
StrPart	Gets a part of a string
StrToVal	Converts a string to a numeric value
ValToStr	Converts a value to a string

For more information on the programming language, see RAPID Reference Manual.

Memory

		Memory size	Instructions[1)]
Program memory:			
Standard		2.5 MB[2)]	7500
Extended memory 8 MB		6.0 MB[2)]	18000
Mass storage[3)]:			
RAM memory	Standard	0.5 MB	3000
	Extended 8 MB	4.0 MB	31000
Diskette		1.44 MB	15000

1) Depending on type of instruction.
2) Some software options reduce the program memory. See Product Specification RobotWare.
3) Requires approx. 3 times less space than in the program memory, i.e. 1 MB mass memory can store 3 MB of RAPID instructions.

Type of diskette: 3.5” 1.44 MB (HD) MS DOS format.
Programs and all user-defined data are stored in ASCII format.

Memory backup

The RAM memory is backed up by two Lithium batteries. Each battery has a typical capacity of >12 months power off time. A warning is given at power on when one of the batteries is empty.

3.6 Automatic Operation

The following production window commands are available:

- Load/select the program.
- Start the program.
- Execute instruction-by-instruction (forward/backward).
- Reduce the velocity temporarily.
- Display program-controlled comments (which tell the operator what is happening).
- Displace a position, also during program execution (can be blocked).

3.7 Maintenance and Troubleshooting

The following maintenance is required:

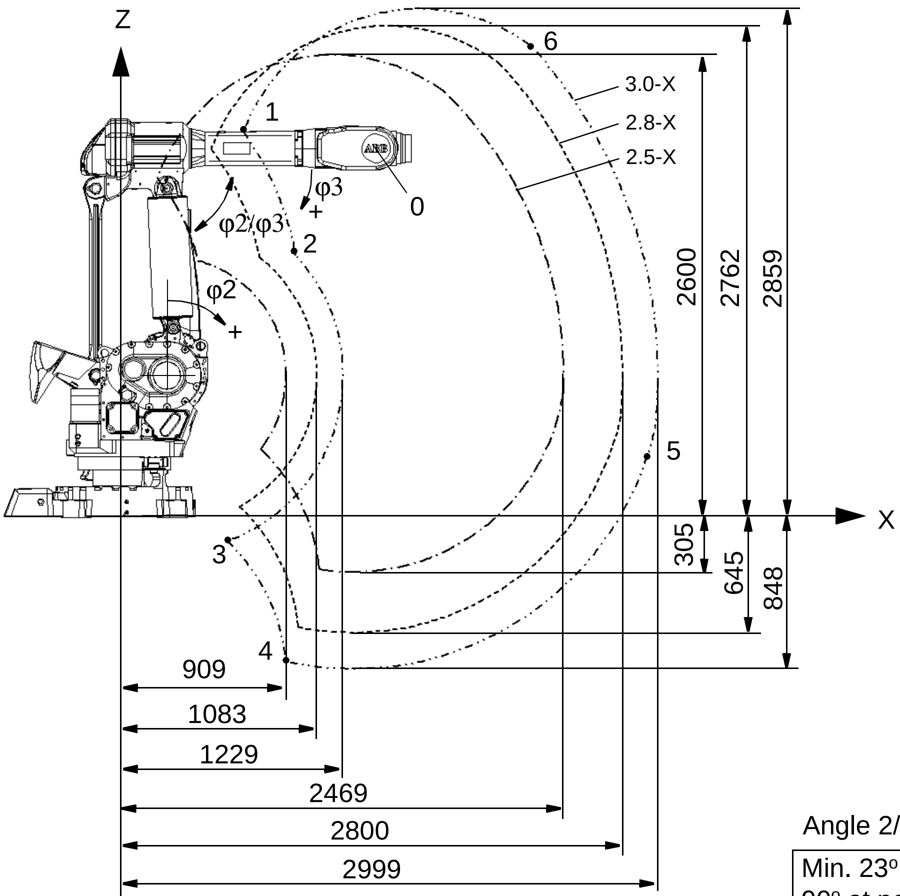
- Changing filter for the transformer/drive unit cooling every year.
- Changing grease and oil every third year.
- Changing batteries every third year.
- Some additional checks every year.

The maintenance intervals depends on the use of the robot. For detailed information on maintenance procedures, see Maintenance section in the Product Manual.

3.8 Robot Motion

IRB 6400R /2.5-120, /2.5-150, /2.5-200, /2.8-150, /2.8-200 and /3.0-100

Type of motion		Range of movement
Axis 1	Rotation motion	$+180^{\circ}$ to -180°
Axis 2	Arm motion	$+85^{\circ}$ to -70°
Axis 3	Arm motion	$+110^{\circ}$ to -28°
Axis 4	Wrist motion	$+300^{\circ}$ to -300°
Axis 5	Bend motion	$+120^{\circ}$ to -120°
Axis 6	Turn motion	$+300^{\circ}$ to -300°



Angle 2/3 (φ2/φ3)

Min. 23° Max. 155°
90° at pos. 0

All dimensions refer to the wrist centre (mm)

Positions at wrist centre (mm)

	2.5 -120 -150 -200		2.8-150 -200		3.0-200	
Pos.	x	z	x	z	x	z
0	1415	2075	1760	2075	1965	2075
1	185	1909	490	2071	671	2168
2	415	1445	760	1463	964	1474
3	766	387	648	63	578	-130
4	1096	-290	978	-614	908	-806
5	2467	701	2791	583	2984	513
6	1804	2389	2108	2551	2289	2647

Angle φ2, φ3 (degrees)

pos.	axis 2 (φ2)	axis 3 (φ3)
0	0	0
1	-70	-28
2	-70	-3
3	43	110
4	85	110
5	85	20
6	37	-28

Figure 26 The extreme positions of the robot arm

Velocity

IRB 6400R versions:	2.5-120 3.0-100	2.5-150 2.5-200 2.8-150	2.8-200
Axis no.			
1	110°/s	100°/s	90°/s
2	100°/s	90°/s	70°/s
3	100°/s	90°/s	70°/s
4	210°/s	120°/s	110°/s
5	150°/s	120°/s	110°/s
6	210°/s	190°/s	110°/s

There is a supervision function to prevent overheating in applications with intensive and frequent movements.

Resolution

Approx. 0.01° on each axis.

3.9 External Axes

An external axis is an AC motor (IRB motor type or similar) controlled via a drive unit mounted in the robot cabinet or in a separate enclosure. See Specification of Variants and Options.

Resolver	Connected directly to motor shaft Transmitter type resolver Voltage ratio 2:1 (rotor: stator)
Resolver supply	5.0 V/4 kHz

Absolute position is accomplished by battery-backed resolver revolution counters in the serial measurement board (SMB). The SMB is located close to the motor(s) according to Figure 27, or inside the cabinet.

For more information on how to install an external axis, see the Product Manual - Installation and Commissioning.

When more than one external axis is used, the drive units for external axis 2 and upwards must be placed in a separate cabinet according to Figure 27.

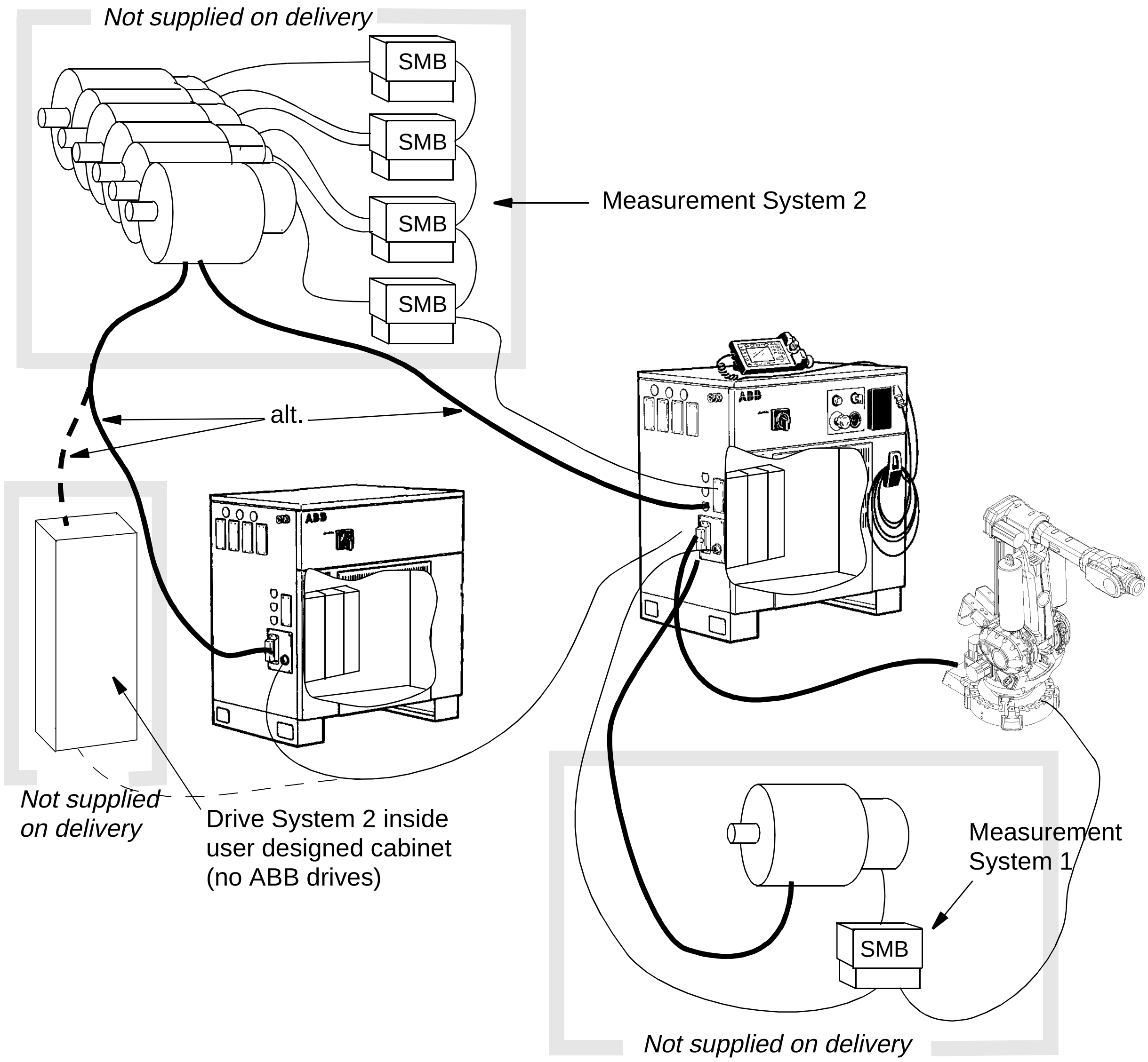


Figure 27 Outline diagram, external axes.

3.10 Inputs and Outputs

Types of connection

The following types of connection are available:

- “Screw terminals” on the I/O units
- Serial interface for distributed I/O units
- Air and signal connections to upper arm
- Distributed I/O-connections on upper arm

For more detailed information, see Chapter 4: *Specification of Variants and Options*.

I/O units

Several I/O units can be used. The following table shows the maximum number of physical signals that can be used on each unit.

Type of unit	Option no.	Digital		Analog			Power supply
		In	Out	Voltage inputs	Voltage output	Current output	
Digital I/O 24 VDC	20x	16	16				Internal/External[1]
Digital I/O 120 VAC	25x	16	16				Internal/External
Analog I/O	22x			4	3	1	Internal
AD Combi I/O	23x	16	16		2		Internal/External[1]
Relay I/O	26x	16	16				Internal/External[1]
Allen-Bradley Remote I/O Slave	281	128[2]	128				
Interbus-S Slave	284-285	64[2]	64				
Profibus DP Slave	286-287	128[2]	128				
Simulated I/O[3]		100	100	30	30		
Encoder interface unit[4]	288-289	1					

1. The digital signals are supplied in groups, each group having 8 inputs or outputs.
2. To calculate the number of logical signals, add 2 status signals for RIO unit and 1 for Interbus-S and Profibus DP.
3. A non physical I/O unit can be used to form cross connections and logical conditions without physical wiring. No. of signals are to be configured. Some ProcessWares include SIM unit.
4. Dedicated for conveyor tracking only.

Distributed I/O

The total number of logical signals is 512 (inputs or outputs, group I/O, analog and digital including field buses)

Max. total no of units*	20 (including SIM units)
Max. total cable length	100 m
Cable type (not included)	According to DeviceNet specification release 1.2
Data rate (fixed)	500 Kbit/s

* Max. four units can be mounted inside the cabinet.

Signal data

Permitted customer 24 V DC load			max.	6 A
Digital inputs	(options 201/203/205)			
24 V DC	Optically-isolated			
	Rated voltage:			24 V DC
	Logical voltage levels:	“1”		15 to 35 V
		“0”		-35 to 5 V
	Input current at rated input voltage:			6 mA
	Potential difference:		max.	500 V
	Time delays:	hardware		5–15 ms
		software		≤ 3 ms
	Time variations:			± 2 ms
Digital outputs	(options 201/203)			
24 V DC	Optically-isolated, short-circuit protected, supply polarity protection			
	Voltage supply			19 to 35 V
	Rated voltage			24 V DC
	Logical voltage levels:	“1”		18 to 34 V
		“0”		< 7 V
	Output current:		max.	0.5 A
	Potential difference:		max.	500 V
	Time delays:	hardware		≤ 1 ms
		software		≤ 2 ms
	Time variations:			± 2 ms
Relay outputs	(option 205)			
	Single pole relays with one make contact (normally open)			
	Rated voltage:			24 V DC, 120 VAC
	Voltage range:			19 to 35 V DC
				24 to 140 V AC
	Output current:		max.	2 A
	Potential difference:		max.	500V
	Time intervals:	hardware (set signal)		typical 13 ms
		hardware (reset signal)		typical 8 ms
		software		≤ 4 ms
Digital inputs				
120 V AC	(option 204)			
	Optically isolated			
	Rated voltage			120 V AC
	Input voltage range:	“1”		90 to 140 V AC
	Input voltage range:	“0”		0 to 45 V AC
	Input current (typical):			7.5 mA
	Time intervals:	hardware		≤ 20 ms
		software		≤ 4 ms

Digital outputs				
120 V AC	(option 204)			
	Optically isolated, voltage spike protection			
	Rated voltage			120 V AC
	Output current:		max.	1A/channel, 12 A 16 channels or
			max.	2A/channel, 10 A 16 channels (56 A in 20 ms)
			min.	30mA
	Voltage range:			24 to 140 V AC
	Potential difference:		max.	500 V
	Off state leakage current:		max.	2mA rms
	On state voltage drop:		max.	1.5 V
	Time intervals:	hardware		≤ 12 ms
		software		≤ 4 ms
Analog inputs	(option 202)			
	Voltage	Input voltage:		±10 V
		Input impedance:		>1 Mohm
		Resolution:		0.61 mV (14 bits)
	Accuracy:			±0.2% of input signal
Analog outputs	(option 202)			
	Voltage	Output voltage:		±10 V
		Load impedance:	min.	2 kohm
		Resolution:		2.44 mV (12 bits)
	Current	Output current:		4-20 mA
		Load impedance:	min.	800 ohm
		Resolution:		4.88 µA (12 bits)
	Accuracy:			±0.2% of output signal
Analog outputs	(option 203)			
	Output voltage (galvanically isolated):			0 to +10 V
	Load impedance:		min.	2 kohm
	Resolution:			2.44 mV (12 bits)
	Accuracy:			±25 mV ±0.5% of output voltage
	Potential difference:		max.	500 V
	Time intervals:	hardware		≤ 2.0 ms
		software		≤ 4 ms

Signal connections on robot arm

Signals	10	50 VAC/DC, 250 mA, AWG24
Power	2 + earth	250 VAC, 8A, 1,0 mm^2
Air	1	Max. 10 bar, inner hose diameter 13 mm
Canbus signals	2	50 VAC/DC, 250 mA, min AWG24
Power	2	50 VAC/DC, 2A, AWG24

System signals

Signals can be assigned to special system functions. Several signals can be given the same functionality.

Digital outputs	Motors on/off Executes program Error Automatic mode Emergency stop Restart not possible Run chain closed
Digital inputs	Motors on/off Starts program from where it is Motors on and program start Starts program from the beginning Stops program Stops program when the program cycle is ready Stops program after current instruction Executes “trap routine” without affecting status of stopped regular program[1] Loads and starts program from the beginning[1] Resets error Resets emergency stop System reset
Analog output	TCP speed signal

1. Program can be decided when configuring the robot.

For more information on system signals, see User’s Guide - System Parameters.

3.11 Communication

The robot has two serial channels - one RS232 and one RS422 Full duplex - which can be used to communicate point to point with printers, terminals, computers and other equipment (see Figure 28).

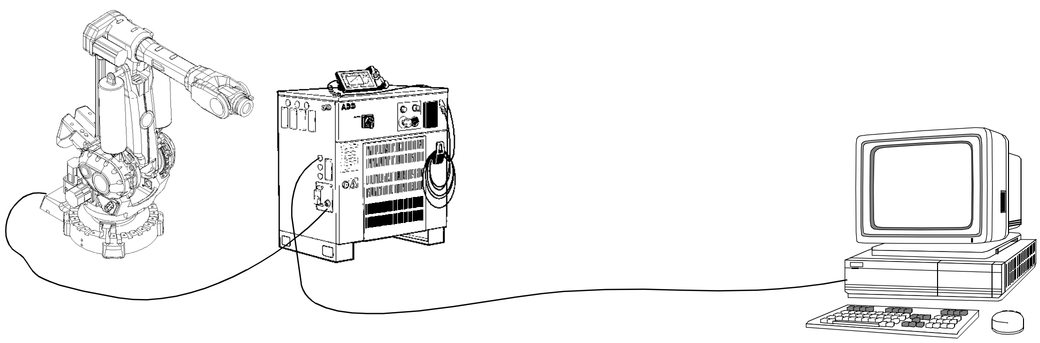


Figure 28 Serial point-to-point communication.

The serial channels can be used at speeds of 300 to 19200 bit/s (max. 1 channel with speed 19200 bit/s).

For high speed and/or network communication, the robot can be equipped with Ethernet interface (see Figure 29). Transmission rate is 10 Mbit/s.

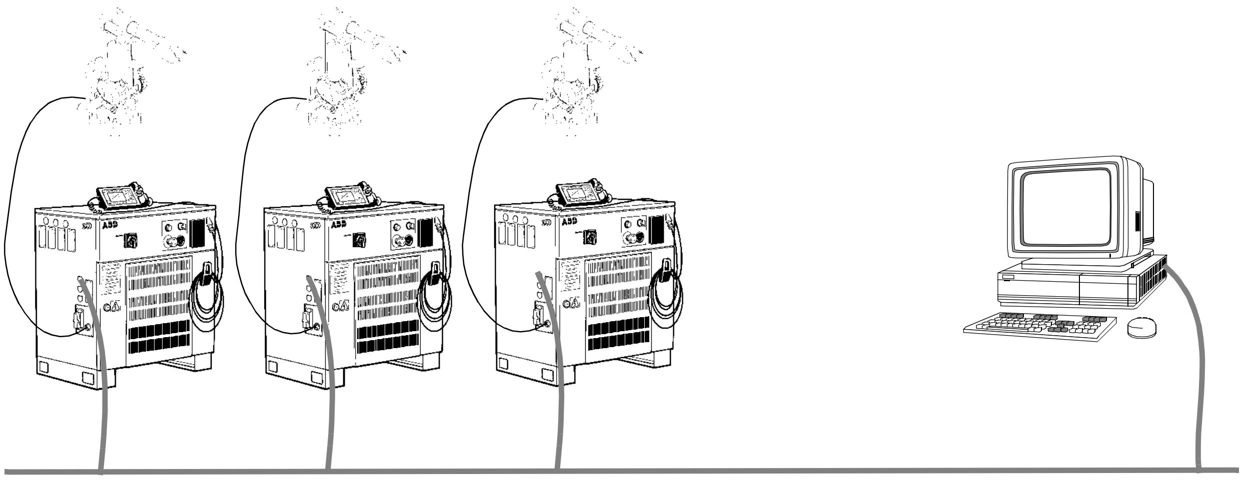


Figure 29 Serial network communication.

Character-based or binary information can be transferred using RAPID instructions. This requires the option Advanced functions, see Product Specification RobotWare.

In addition to the physical channels, a Robot Application Protocol (RAP) can be used. This requires either of the options FactoryWare Interface or RAP Communication, see Product Specification RobotWare.

3.12 **Spotweld Harness** (option)

Specification:

Type 25	Power	2 x 25 mm^2
	Earth	1 x 25 mm^2
	Water	3, max 10 bar, innerhose diameter 13 mm
Max current		2,5 kA/1s
(Short-circuit current)		1,5 kA/3s
Max average current		135 A (at +20^{o}C (68^{o}F) ambient temperature)
		100 A (at +50^{o}C (122^{o}F) ambient temperature)
Max voltage		600 V
Frequency		50 - 1000 Hz
Lifetime		4 years of 3-shift (1800000 cycles ±180^o)

4 Specification of Variants and Options

The different variants and options for the IRB 6400R are described below.
The same numbers are used here as in the Specification form. For software options, see Product Specification RobotWare.

Note Options marked with * are inconsistent with UL/UR approval.

1 MANIPULATOR

VARIANTS

022 IRB 6400R/2.5-120
023 IRB 6400R/2.5-150
024 IRB 6400R/2.5-200
025 IRB 6400R/2.8-150
026 IRB 6400R/2.8-200
027 IRB 6400R/3.0-100

IRB 6400R*/Reach-Handling capacity*

Reach:	Specifies the max. reach at the wrist centre.
Handling capacity:	Specifies the max. handling capacity.

Manipulator colour

The manipulator is painted with ABB orange if no colour is specified.

310-320 Colours according to RAL-codes.

Protection

035 Standard

036 Foundry
Robot adapted for foundry environments. Degree of protection as in Chapter 3.4.
The manipulator is specially painted and finished.

039 **Extra load upper arm**
This option should be chosen if the weight of extra equipment on the upper arm exceeds 50 kg. (The manipulator is then equipped with different balancing cylinders for axis 2). For more information, see Mounting equipment on page 31.
Not available for options 026, 027.

APPLICATION INTERFACE

A hose for compressed air is integrated into the manipulator. There is an inlet at the base, see Figure 31, and an outlet on the upper arm housing or on the upper arm axis 4, see Figure 30.
Connection: G 1/2”-14 in the upper arm housing/upper arm and G 1/2”-14 at the base.

For connection of extra equipment on the manipulator, there are cables running parallel to the manipulator’s cable harness with connectors on the upper arm axis 4 or on the upper arm housing. The connectors are:

- one Burndy 12-pin UT071412 SHT
- one Burndy 4-pin UT07104 SHT
- one fieldbus (options 053-055)

041 At upper arm housing

042 At upper arm axis 4

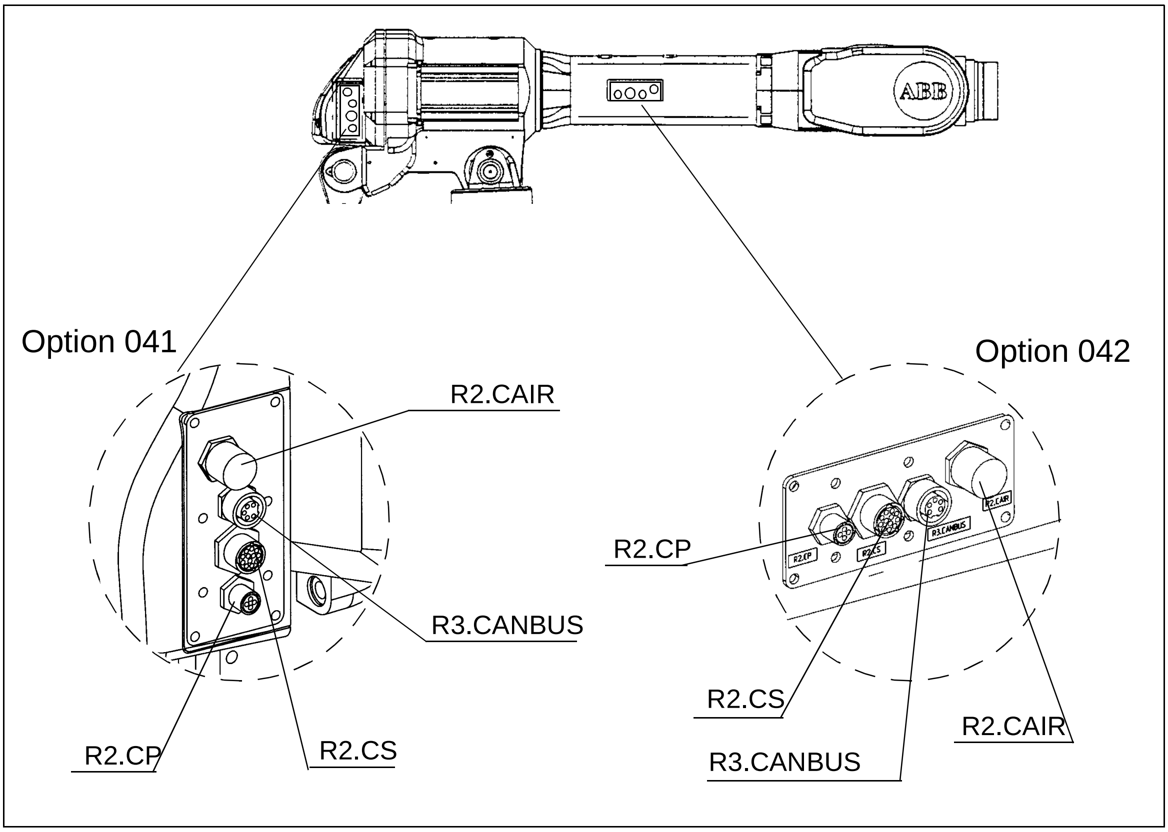


Figure 30 Location of customer connections on upper arm / armhouse.

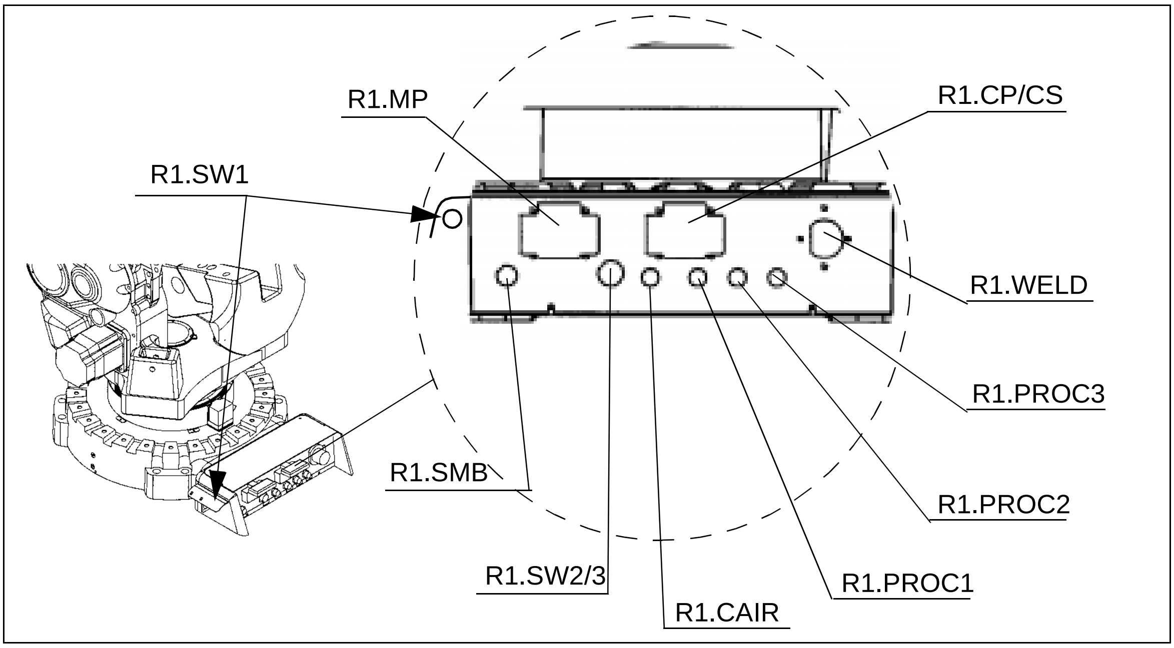


Figure 31 Location of customer connections on base.

Connection of signals

056 Manipulator
The signals are connected directly to the robot base to one heavy duty industrial housing with three D-sub connector inserts, R1.CP/CS (see Figure 31).
The cables from the manipulator base are not supplied.

057 Cabinet
The signals CP/CS are connected to 12-pole screw terminals, Phoenix MSTB 2.5/12-ST-5.08, in the controller (see Figure 41).
The cable between R1.CP/CS and the controller is supplied.

Connectors type
Type of fieldbus connector on the upper arm

053 Canbus R3.CANBUS
5-pin “Mini” style female contact with 7/8-16 UN-2A THD female connection thread. Rotation Required. Meets ANSI/B93.55M-1981 design and intermateability requirements.

Connection to cabinet (Cable lengths)

Canbus

660 7m
661 15m
662 22m
663 30m

047 **Spotweld Harness**
Integrated spotweld harness with primary current (R1.WELD) and water supplies (R1.PROC1-3). Connected to the upper arm housing, see Figure 32 and to the manipulator base, see Figure 31.

The harness remains within the manipulator’s max. radius envelope for axis 1.
This option is only available if option 041 is chosen.

Connection on the manipulator base:	Current; Multi-Contact TSS+2/25
	Water; G1/2”-14 outer thread
Connection on the upper arm housing:	Current; Multi-Contact TSB+2/25
	Water; G1/2”-14 outer thread

This option is not available if option 050 Process media conduit is chosen.

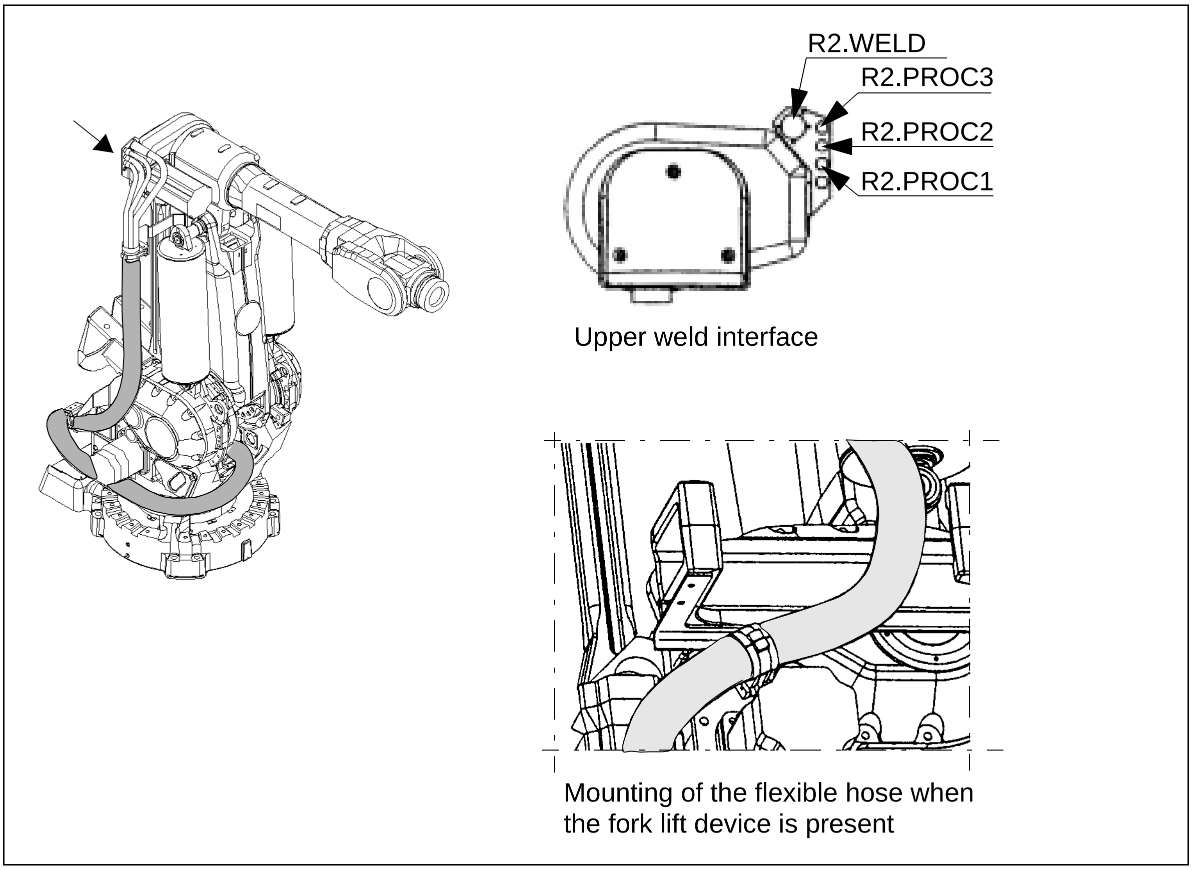


Figure 32 Mounted Spotweld harness.

050 Process media conduit

An external flexible condiut for supplying process media from the base up to the upper arm housing. The flexible hose has the diameter of 80/67 mm. The harness remains within the manipulators max envelope for axis 1 of 530 mm. The flexibel hose is attached to the base, frame and lower arm. See Figure 33.

The hoses/cables inside the conduit is to be designed by the user. Cable hose clamps in both ends. The clamps are included.

This option is not available if option 047 Spotweld Harness is chosen.

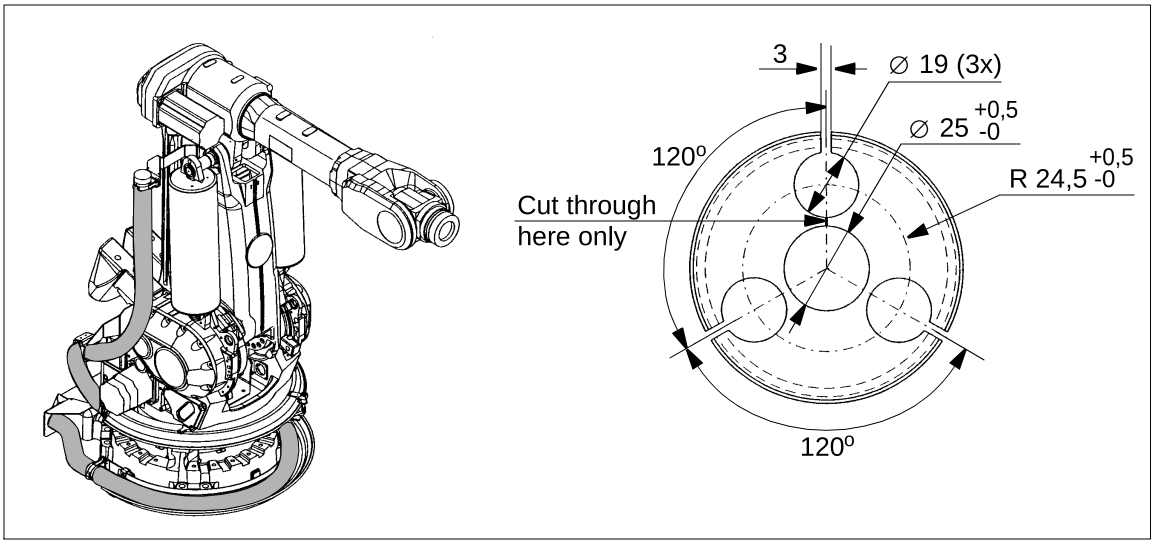


Figure 33 Mounted Process media conduit and cable hose clamp (dimensions in mm).

EQUIPMENT

091 Brake release cover
Protective cover over push-buttons on brake release unit.
Always included for Foundry versions.

090 Cooling for axis 1 motor
Extra cooling of axis 1 motor is recommended in heavy duty application e.g. in press tending application.

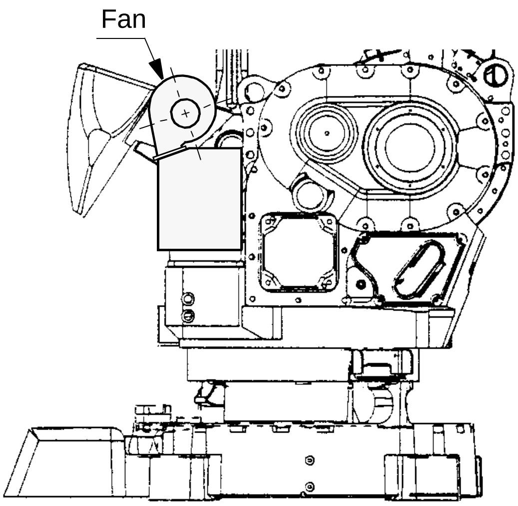


Figure 34 Location of the fan on the manipulator.

092 Fork lift device
Lifting device on the manipulator for fork-lift handling is mounted at delivery.
Lifting eyes for use with an overhead crane are integrated as standard.

691 Safety lamp
A safety lamp with an orange fixed light can be mounted on the manipulator.
The lamp is active in MOTORS ON mode.
The safety lamp is required on a UL/UR approved robot.

058 Dressing
Mounting of extra equipment, e.g. tool system on robot before delivery, ordered from ABB Flexible Automation/*Dpt U*.

089 Insulated flange
Electrically insulated tool flange. In case of an electrical fault in the spot welding equipment mounted on the tool flange, the tool flange withstands dangerous voltage (100V AC during 60 seconds or 300V AC during 10 seconds) in non water applications without passing it further to electronics in the robot and controller.
See Figure 35.

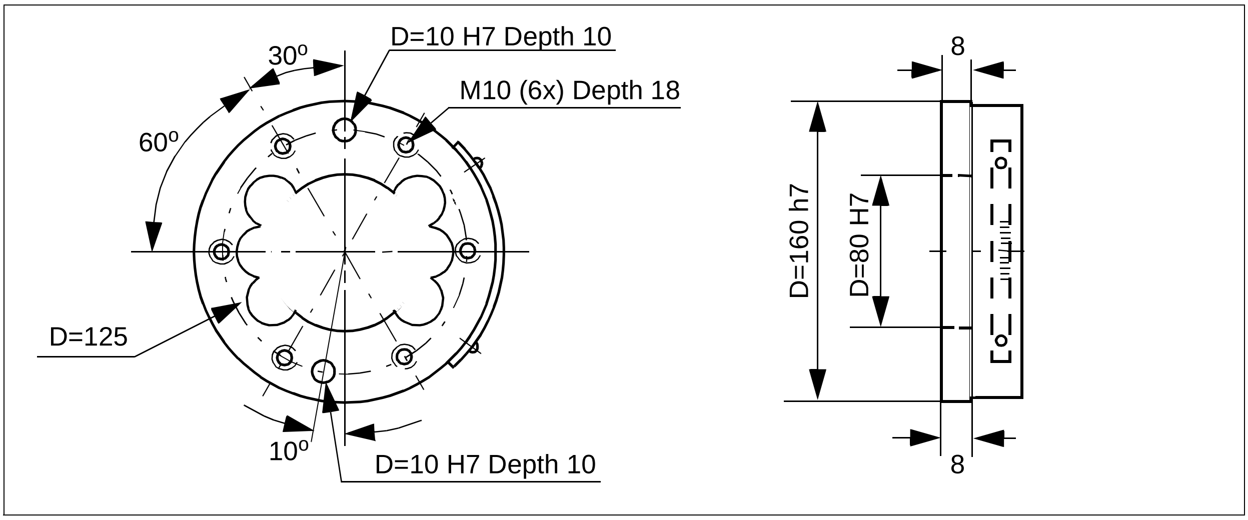


Figure 35 The mechanical interface of the insulated flange (dimensions in mm).

093 Onboard calibration

Onboard calibration is used to make short service stops possible, in order to check on the sync position or any displacement of the screwed joints in the structure, following a collision, seizure with a tool, when one of the motors on axes 1-4 is changed, etc.

In connection with major repairs and changing structural components or the wrist, DynaCal must be used instead.

The equipment comprises four sensors fixed on the manipulator axes 1-4.

A calibration tool is also required, with two sensors for axes 5-6, an I/O connection box with six sensor cables of length 5 m, and a CANbus cable of length 15 m with a Phoenix connector that is plugged into X16 in the control cabinet.

This equipment must be ordered separately.

POSITION SWITCHES

Position switches indicating the position of the three main axes. Rails with separate adjustable cams are attached to the manipulator. The cams, which have to be adapted to the switch function by the user, can be mounted in any position in the working range for each switch. No machining operation of the cams is necessary for the adaption, simple hand tools can be used.

For axis 1 there are three position switch functions available. For axes 2 and 3 one position switch function each.
Each position switch function consists of two switches mechanically operated by separate cams. Each switch has one normal open and one normal closed contact. See the exception for axis 1.
The design and components fulfill the demands to be used as safety switches.
This options may require external safety arrangements, e.g. light curtains, photocells or contact mats.

The switches can be connected either to the manipulator base (R1.SW1or R1.SW2/3, see Figure 31), or to the controller. In the controller the signals are connected to screw terminal XT8 Phoenix MSTB 2.5/12-ST-5.08, see Figure 41.
Switch type Balluff Multiple position switches BNS, according to EN 60947-5-1 and EN 60947-5-2.

Connection to

075 Manipulator
Connection on the manipulator base with one Burndy 23-pin connector.

076 Cabinet
Connection on the cabinet wall. Position switch cables are included.

Position switches axis 1

069- Three position switch functions are available.
071 Note. With 3 functions the connection of the switch no 5 and 6 is limited to normal closed as standard.

Connection of signals axis 1 (cable lengths)

078 7m
079 15m
080 22m
081 30m

072 **Position switches axis 2**
Only available if option 041 or 042 is chosen

073 **Position switches axis 3**
Only available if options 041 or 042, and 072 are chosen

Connection of signals axes 2 and 3 (cable lengths)

083 7m
084 15m
085 22m
086 30m

WORKING RANGE LIMIT

To increase the safety of the robot, the working range of axes 1, 2 and 3 can be restricted by extra mechanical stops.

Axis 1

061 Stops which allow the working range to be restricted in increments of 7,5^{o}.
062 Stops which allow the working range to be restricted in increments of 15^{o} .

063 Axis 2
Six stops which allow the working range to be restricted in increments of 15^o at both end positions. Each stop decreases the motion by 15^o. The motion of axis 2 can be decreased by $5x15^o$ from the maximum axis motion.

064 Axis 3
Six stops which allow the working range to be restricted in increments of 15^oat both end positions. Each stop decreases the motion by 15^o. The motion of axis 3 can be decreased by $5x15^o$ from the maximum axis motion.

2 SAFETY STANDARDS

EU - Electromagnetic Compatibility

693 The robot complies with the European Union Directive “Electromagnetic Compatibility” 89/336/EEC. This option is required by law for end users in the European Union.

UNDERWRITERS LABORATORY

Option 691 Safety lamp is included on UL and UR robots.

695 **UL Listed**, certificate on product level.
Underwriters Laboratories Inc. has tested and examined the finished complete product, i.e. manipulator and controller, and determined that the product fulfils the stipulated safety standards.
Some options marked with * are inconstistent with UL Listed.
Option 112 Standard cabinet without upper cover can not be UL Listed at delivery, it may be ordered as UL Recognized.

696 **UR Recognized**, certificate on component level.
Underwriters Laboratories Inc. has tested and examined the components in the product, manipulator and controller, and determined that they fulfil the stipulated safety standards.

3 CONTROL SYSTEM

CABINET

Variant

111 Standard cabinet with upper cover.

Cabinet Height

121 Standard cabinet with upper cover.

122* Standard cabinet without upper cover. To be used when cabinet extension is mounted on top of the cabinet after delivery.

123* Standard cabinet with 250 mm extension. The height of the cover increases the available space for external equipment that can be mounted inside the cabinet.

124* The extension is mounted on top of the standard cabinet. There is a mounting plate inside. (See Figure 36).

The cabinet extension is opened via a front door and it has no floor. The upper part of the standard cabinet is therefore accessible.
This option cannot be combined with options 141 or 145.

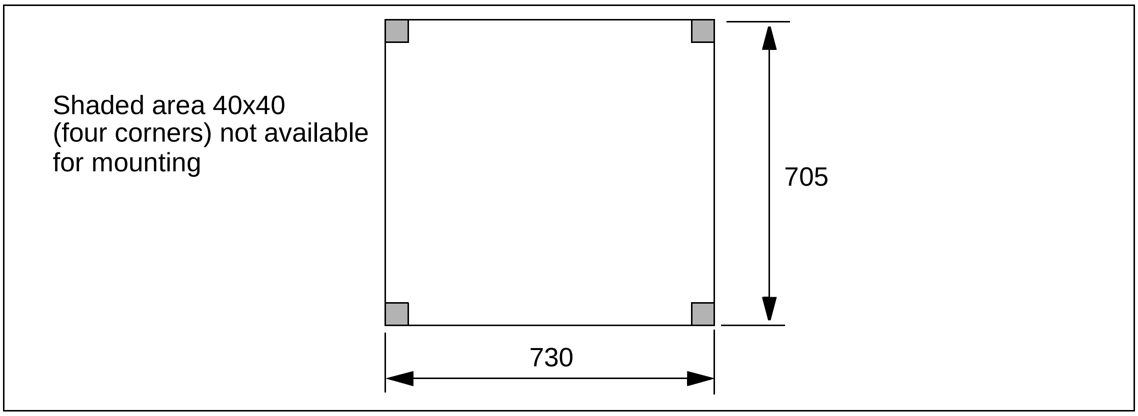


Figure 36 Mounting plate for mounting of equipment (dimensions in mm)

126 Cabinet on wheels.

OPERATOR’S PANEL

The operator’s panel and teach pendant holder can be installed either

181 Standard, i.e. on the front of the cabinet, or

182 External, i.e. in a separate operator’s unit. (See Figure 37 for required preparation)
All necessary cabling, including flange, connectors, sealing strips, screws, etc., is supplied.
External enclosure is not supplied.

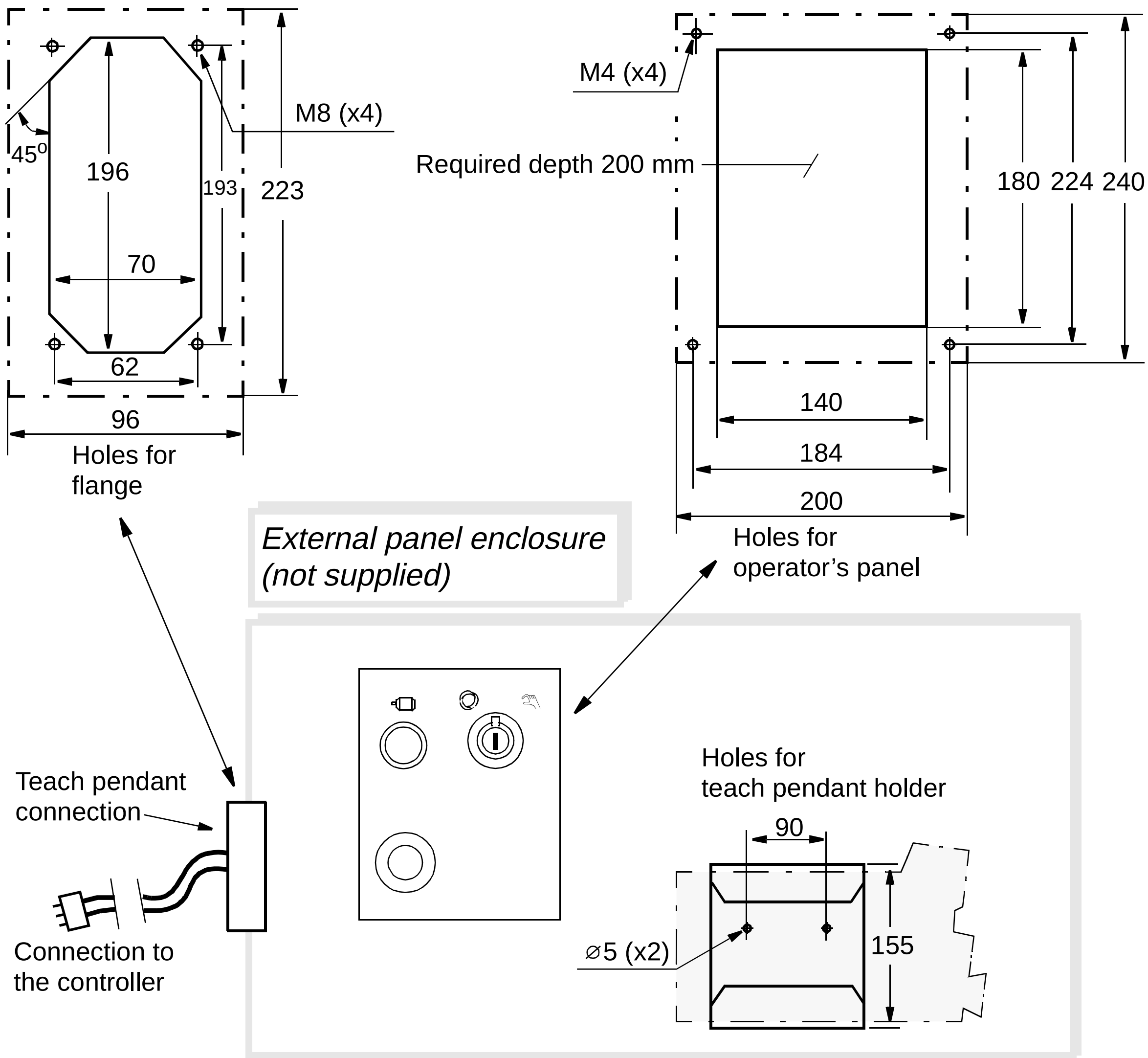


Figure 37 Required preparation of external panel enclosure (all dimensions in mm).

183 External, mounted in a box. (See Figure 38)

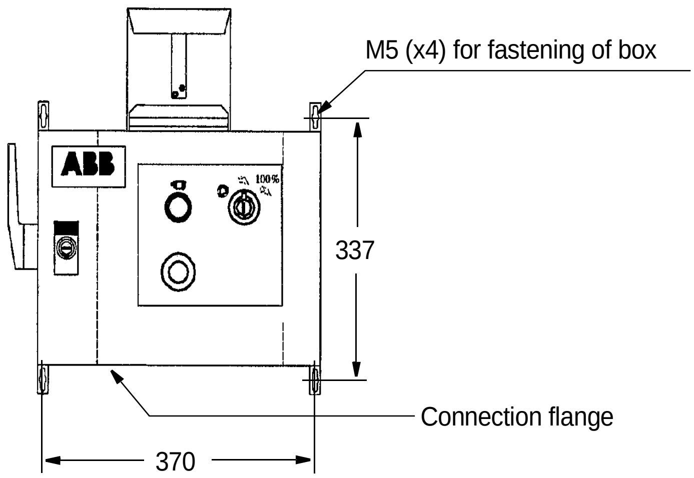


Figure 38 Operator’s panel mounted in a box (all dimensions in mm).

EXTERNAL CABLE LENGTH (for external panel)

185 15 m
186 22 m
187 30 m

DOOR KEYS

461 Standard

462 DIN 3 mm

463 Square outside 7 mm

464 EMKA

OPERATING MODE SELECTOR

193 Standard, 2 modes: manual and automatic

191* Standard, 3 modes: manual, manual full speed and automatic.

COOLING FOR DISK DRIVE

472 Cooling for disk drive
The disk drive normally works well at temperatures up to 40ºC (104ºF). At higher temperatures a cooling device for the drive is necessary to ensure good functionality. The disk drive will not deteriorate at higher temperatures but there will be an increase in the number of reading/writing problems as the temperature increases.

TEACH PENDANT

601 Teach pendant with back lighting

Teach pendant language:

611 English
612 Swedish
613 German
614 French
615 Spanish
616 Portuguese
617 Danish
618 Italian
619 Dutch
620 Japanese
621 Czech

Extension cable for the teach pendant:

606 10 m
This can be connected between the controller and the connector on the teach pendant's cable.

A maximum of two extension cables may be used; i.e. the total length of cable between the controller and the teach pendant should not exceed 30 m.

607 **2 x 10 m**

MAINS VOLTAGE

The robot can be connected to a rated voltage of between 200 V and 600 V, 3-phase and protective earthing. A voltage fluctuation of +10% to -15% is permissible in each connection.

151-	Voltage	Voltage	Voltage
163	200 V		
	220 V		
	400 V	400 V	
	440 V	440 V	
		475 V	475 V
		500 V	500 V
			525 V
			600 V

MAINS CONNECTION TYPE

The power is connected either inside the cabinet or to a connector on the cabinet's left-hand side. The cable is not supplied. If option 133-136 is chosen, the female connector (cable part) is included.

131 Cable gland for inside connection. Diameter of cable: 11-12 mm.

132* 32 A, 380-415 V, 3p + PE (see Figure 39).

133* 32 A, 380-415 V, 3p + N + PE (see Figure 39).

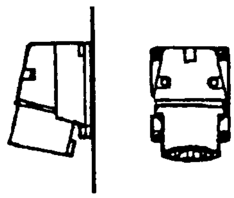


Figure 39 CEE male connector.

134 Connection via an industrial Harting 6HSB connector in accordance with DIN 41640.
35 A, 600 V, 6p + PE (see Figure 40).

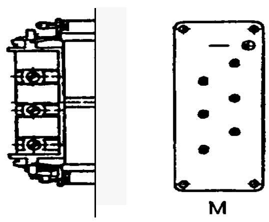


Figure 40 DIN male connector.

MAINS SWITCH

141* Rotary switch in accordance with the standard in section 3.2 and IEC 337-1, VDE 0113. Customer fuses for cable protection required.

142 Flange disconnect (20 A) in accordance with the standard in section 3.2. Includes door interlock. Interrupt capacity 14 kA.

144 Servo disconnector.
This option adds a mechanical switch to the two series connected motors on

contactors. The switch is operated by the same type of handle as the rotary mains switch. The handle can be locked by a padlock, e.g. in an off position.

145 Door interlock. Includes rotary switch.

147 Circuit breaker for rotary switch. A 16 A (transformer 2 and 3) or 25 A (transformer 1) circuit breaker for short circuit protection of mains cables in the cabinet. Circuit breaker approved in accordance with IEC 898, VDE 0660. Interrupt capacity 3 kA.

148 Fuses (3x15 A) for the rotary switch for short circuit protection of mains cables in the cabinet. Interrupt capacity 50 kA.

I/O INTERFACES

The standard cabinet can be equipped with up to four I/O units. For more details, see Technical Specification 3.10.

Note The use of I/O units and field buses can be limited because of CPU overload in the controller during motions.

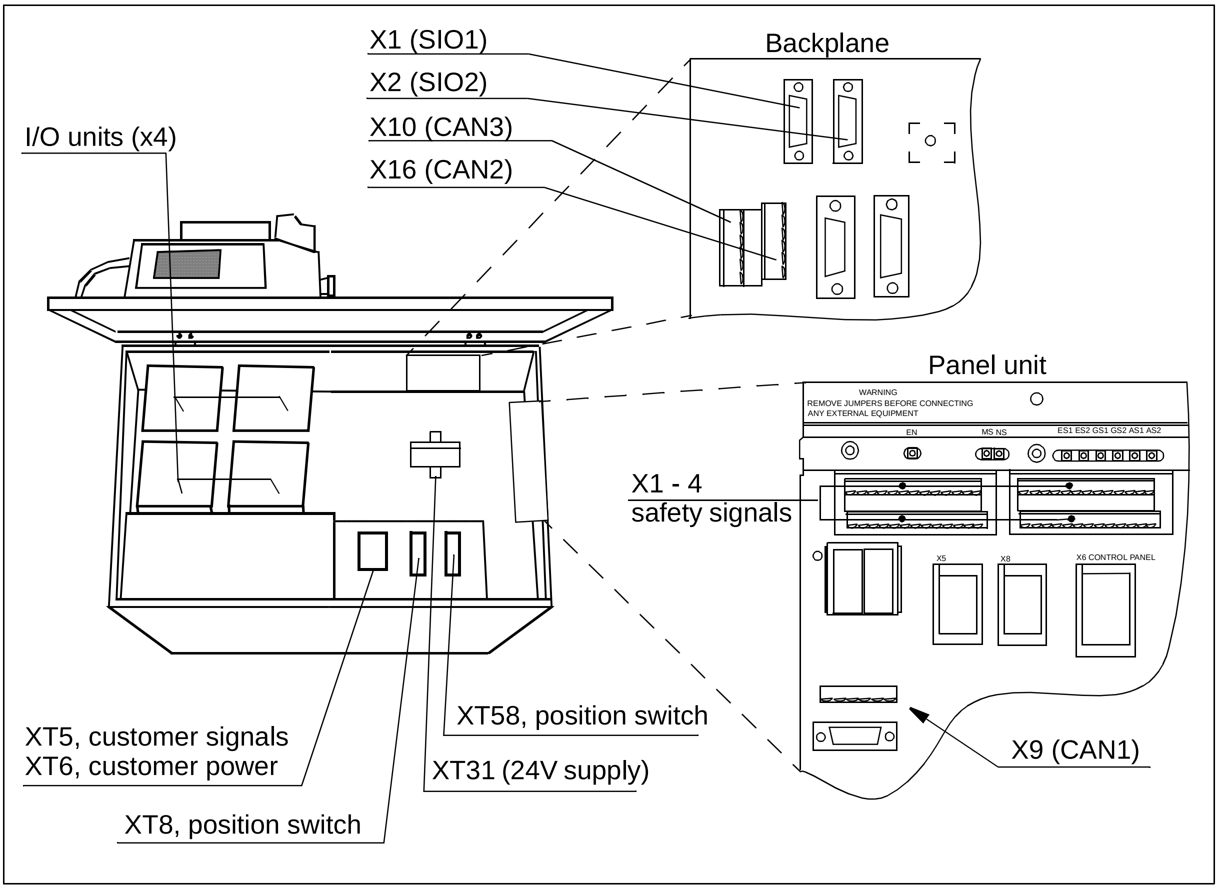


Figure 41 I/O unit and screw terminal locations.

201 Digital 24 VDC I/O: 16 inputs/16 outputs.

202 Analog I/O: 4 inputs/4 outputs.

203 AD Combi I/O: 16 digital inputs/16 digital outputs and 2 analog outputs (0-10V).

204 Digital 120 VAC I/O 16 inputs/16 outputs.

205 Digital I/O with relay outputs: 16 inputs/16 outputs.
Relay outputs to be used when more current or voltage is required from the digital outputs. The inputs are not separated by relays.

Connection of I/O

251 **Internal connection** (options 201-204, 221-224, 231-234, 251-254, 261-264)
The signals are connected directly to screw terminals on the I/O units in the upper part of the cabinet (see Figure 41).

252 **External connection**
The signals are connected via 64-pole standard industrial connector in accordance with DIN 43652. The connector is located on the left-hand side of the controller. Corresponding customer part is included.

SAFETY SIGNALS

206 **Internal connection**
The signals are connected directly to screw terminals in the upper part of the cabinet (see Figure 41).

207 **External connection**
The signals are connected via 64-pole standard industrial connector in accordance with DIN 43652. The connector is located on the left-hand side of the controller. Corresponding customer part is included.

FIELD BUSES, SLAVE

For more details, see Technical Specification 3.10.

241 **Allen-Bradley Remote I/O**
Up to 128 digital inputs and outputs, in groups of 32, can be transferred serially to a PLC equipped with an Allen Bradley 1771 RIO node adapter. The unit reduces the number of I/O units that can be mounted in cabinet by one. The field bus cables are connected directly to the A-B RIO unit in the upper part of the cabinet (see Figure 41). Connectors Phoenix MSTB 2.5/xx-ST-5.08 or equivalent are included.

242 **Interbus-S Slave**
Up to 64 digital inputs and 64 digital outputs can be transferred serially to a PLC equipped with an InterBus-S interface. The unit reduces the number of I/O units that can be mounted in the cabinet by one. The signals are connected directly to the InterBus-S slave unit (two 9-pole D-sub) in the upper part of the cabinet.

243 **Profibus DP Slave**
Up to 128 digital inputs and 128 digital outputs can be transferred serially to a PLC equipped with a Profibus DP interface. The unit reduces the number of I/O units that can be mounted in the cabinet by one. The signals are connected directly to the Profibus DP slave unit (one 9-pole D-sub) in the upper part of the cabinet.

244 **Encoder interface unit for conveyor tracking**
Conveyor Tracking, or Line Tracking, is the function whereby the robot follows a work object which is mounted on a moving conveyor. The encoder and

synchronization switch cables are connected directly to the encoder unit in the upper part of the cabinet (see Figure 41). Screw connector is included. For more information see Product Specification RobotWare.

245 **DeviceNet**
Connection on the left side to a 5-pole connector in accordance with ANSI.

NETWORK

As standard, the robot is equipped with one RS232 (SIO 1) and one RS422 (SIO 2) connector inside the cabinet. The signals are connected to 9-pole D-sub connectors on the backplane. See Figure 28 and Figure 41.

292 Ethernet (see Figure 29). Connectors: RJ45 and AUI on the board front.

EXTERNAL I/O UNITS

I/O units can be delivered separately. The units can then be mounted outside the cabinet or in the cabinet extension. These are connected in a chain to a connector (CAN 3 or CAN 2, see Figure 41) in the upper part of the cabinet. Connectors to the I/O units and a connector to the cabinet (Phoenix MSTB 2.5/xx-ST-5.08), but no cabling, is included. Measures according to Figure 42 and Figure 43.
For more details, see Technical Specification 3.10.

221 Digital I/O 24 V DC: 16 inputs/16 outputs.

222 Analog I/O.

223 AD Combi I/O: 16 digital inputs/16 digital outputs and 2 analog outputs (0-10V).

224 Digital I/O 120 V AC: 16 inputs/16 outputs.

225 Digital I/O with relay outputs: 16 inputs/16 outputs.

EXTERNAL FIELD BUSES

231 Allen Bradley Remote I/O

232 Interbus-S Slave

233 Profibus DP Slave

234 Encoder interface unit for conveyor tracking

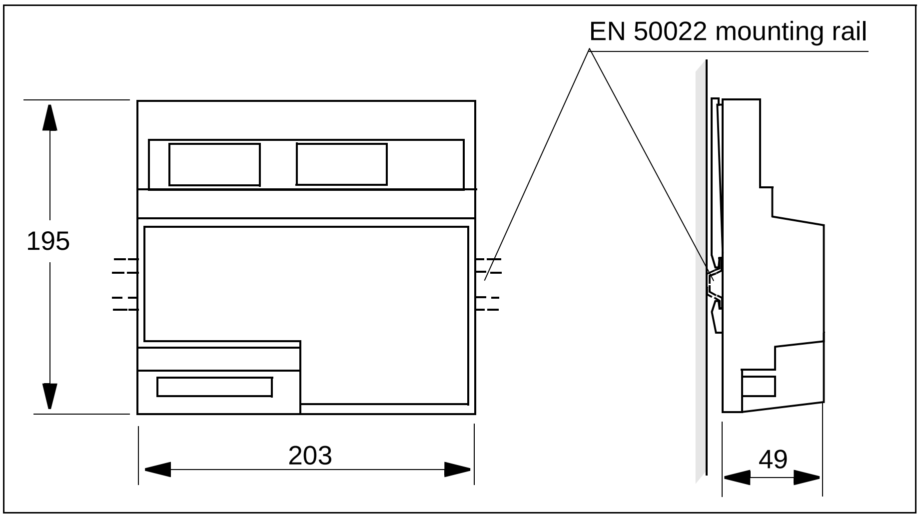


Figure 42 Dimensions for units 221-225.

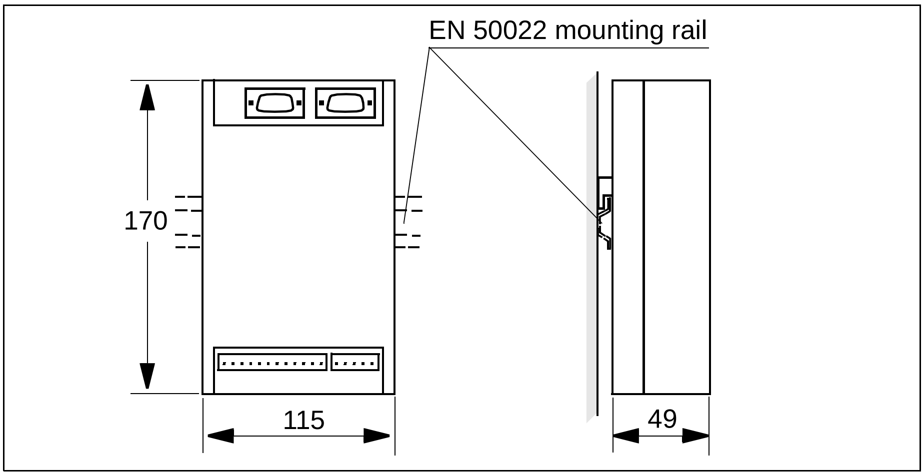


Figure 43 Dimension for units 231-234.

EXTERNAL AXES IN ROBOT CABINET

It is possible to equip the controller with drives for external axes. The motors are connected to a standard industrial 64-pin female connector, in accordance with DIN 43652, on the left-hand side of the cabinet. (Male connector is also supplied.)

391 Drive unit C
The drive unit is part of the DC-link. Recommended motor type see Figure 44.

397 Drive unit U
The drive unit is part of the DC-link. Recommended motor types see Figure 44.

EXTERNAL AXES MEASUREMENT BOARD

The resolver can either be connected to a serial measurement board outside the controller, or to a measurement board inside the cabinet.

386 Serial measurement board inside cabinet
Signal interface to external axes with absolute position at power on. The board is located in the cabinet and occupies one I/O unit slot. The resolvers are connected to a standard industrial 64-pin connector in accordance with DIN 43652, on the left-hand side of the cabinet.

387 Serial measurement board as separate unit

370 EXTERNAL AXES DRIVES - SEPARATE CABINET

If more external axes than in option 390 are to be used, an external cabinet can be supplied. The external cabinet is connected to one Harting connector (cable length 7 m) on the left-hand side of the robot controller.

Door interlock, mains connection, mains voltage and mains filter according to the robot controller. One transformer and one mains switch are included.

371/372 Drive unit GT, for 4 or 6 motors. Recommended motor types see Figure 44.

373 Drive unit ECB, for 3 or 6 motors. Recommended motor types see Figure 44.

374 Drive unit GT + ECB

375 Drive unit GT + GT + ECB

Drive unit data	Max current	Rated current	Motor type[1]
U	11 - 55A $_{rms}$	24A $_{rms}$	M, L
G	6 - 30A $_{rms}$	16A $_{rms}$	S, M, L
T	7,5 - 37A $_{rms}$	20A $_{rms}$	S, M, L
E	4 - 19A $_{rms}$	8,4A $_{rms}$	
C	2,5 - 11A $_{rms}$	5A $_{rms}$	
B	1,5 - 7A $_{rms}$	4A $_{rms}$	

1. Motors from ABB Flexible Automation/System Products.
Types: S=small (T_N=1,7 Nm), M=medium (T_N=5 Nm), L=large (T_N=12 Nm)

Figure 44 Motor selecting table.

MANIPULATOR CABLE

The cables are available in the following lengths:

641-646
7m
15 m
22 m
30 m
7 m, metal braided
15 m, metal braided

SERVICE OUTLET

Any of the following standard outlets with protective earthing can be chosen for maintenance purposes.
The maximum load permitted is 500 VA (max. 100 W can be installed inside the cabinet).

421* 230 V mains outlet in accordance with DIN VDE 0620; single socket suitable for Sweden, Germany and other countries.

422* 230 V in accordance with French standard; single socket.

423* 120 V in accordance with British standard; single socket.

424 120 V in accordance with American standard; single socket, Harvey Hubble.

425* Service outlet according to 421 and a computer connection on the front of the cabinet. The computer connection is connected to the RS232 serial channel. Cannot be used if option 142 is chosen.

POWER SUPPLY

431 Connection from the main transformer.
The voltage is switched on/off by the mains switch on the front of the cabinet.

432 Connection before mains switch without transformer.
Note this only applies when the mains voltage is 400 V, three-phase with neutral connection and a 230 V service socket.
Note! Connection before mains switch is not in compliance with some national standards, NFPL 79 for example.

433 Connection before mains switch with an additional transformer for line voltages 400-500 V and with a secondary voltage of 115 V or 230 V, 2A.
Note! Connection before mains switch is not in compliance with some national standards, NFPL 79 for example.

440 Earth fault protection for service outlet.
To increase personal safety, the service outlet can be supplied with an earth fault protection which trips at 30 mA earth current. The earth fault protection is placed next to the service outlet (see Figure 41). Voltage range: 110 - 240 V AC.

RAM MEMORY

402 Standard, total memory 8+8 MB

403 Extended memory, total 8+16 MB

5 Accessories

There is a range of tools and equipment available, specially designed for the robot.

Software options for robot and PC

For more information, see Product Specification RobotWare

Robot Peripherals

- Track Motion
- Tool System
- Motor Units
- Spot welding system for transformer gun

CONTENTS

Page

1 Introduction

RobotWare is a family of software products from ABB Flexible Automation designed to make you more productive and lower your cost of owning and operating a robot.

ABB Flexible Automation has invested many man-years into the development of these products and they represent knowledge and experience based on several thousand robot installations.

Within the RobotWare family there are three classes of products:

BaseWare OS - This is the operating system of the robot and constitutes the kernel of the RobotWare family. BaseWare OS provides all the necessary features for fundamental robot programming and operation. It is an inherent part of the robot but can be provided separately for upgrading purposes.

BaseWare Options - These products are options that run on top of BaseWare OS of the robot. They represent functionality for robot users that need additional functionality, for example run multitasking, transfer information from file to robot, communicate with a PC, perform advanced motion tasks etc.

ProcessWare - ProcessWare products are designed for specific process applications like welding, gluing and painting. They are primarily designed to improve the process result and to simplify installation and programming of applications. These products also run on top of BaseWare OS.

2 BaseWare OS

Only a very superficial overview of BaseWare OS is given here. For details, see references in *Robot Documentation*.

The properties of BaseWare OS can be split up in five main areas: The Rapid Language and Environment; Exception handling; Motion Control; Safety; the I/O System.

2.1 The Rapid Language and Environment

The Rapid language is a well balanced combination of simplicity, flexibility and powerfulness. It contains the following concepts:

- Hierarchical and modular program structure to support structured programming and reuse.
- Routines can be Functions or Procedures.
- Local or global data and routines.
- Data typing, including structured and array data types.
- User defined names (shop floor language) on variables, routines and I/O.
- Extensive program flow control.
- Arithmetic and logical expressions.
- Interrupt handling.
- Error handling (for exception handling in general, see *Exception handling*).
- User defined instructions (appear as an inherent part of the system).
- Backward handler (user definition of how a procedure should behave when stepping backwards).
- Many powerful built-in functions, e.g mathematics and robot specific.
- Unlimited language (no max. number of variables etc., only memory limited).
- Windows based man machine interface with built-in Rapid support (e.g. user defined pick lists).

2.2 Exception handling

Many advanced features are available to make fast error recovery possible. Characteristic is that the error recovery features are easy to adapt to a specific installation in order to minimise down time. Examples:

- Error Handlers (automatic recovery often possible without stopping production).
- Restart on Path.
- Power failure restart.
- Service routines.
- Error messages: plain text with remedy suggestions, user defined messages.
- Diagnostic tests.
- Event logging.

2.3 Motion Control

TrueMove™

Very accurate path and speed, based on advanced dynamic modelling. Speed independent path. Flexible and intuitive way to specify corner zones (e.g. possibility to have separate zone sizes for Tool Centre Point (TCP) path and for tool reorientation).

QuickMove™

By use of the dynamic model, the robot always and automatically optimises its performance for the shortest possible cycle time. No need for manual tuning! This is achieved without compromising the path accuracy.

Coordinate Systems

A very powerful concept of multiple coordinate systems that facilitates jogging, program adjustment, copying between robots, off-line programming, sensor based applications, external axes co-ordination etc. Full support for TCP attached to the robot or fixed in the cell (“Stationary TCP”). Note that also joint coordinate movements (MoveJ) are recalculated when a coordinate system is adjusted.

Singularity handling

The robot can pass through singular points in a controlled way, i.e. points where two axes coincide.

Motion Supervision

The behaviour of the motion system is continuously monitored as regards position and speed level to detect abnormal conditions and quickly stop the robot if something is not OK. A further monitoring function, Collision Detection, is optional (see option “Load Identification and Collision Detection”).

External axes

Very flexible possibilities to configure external axes. Includes for instance high performance coordination with robot movement and shared drive unit for several axes.

Big Inertia

One side effect of the dynamic model concept is that the system can handle very big load inertias by automatically adapting the performance to a suitable level. For big, flexible objects it is possible to optimise the servo tuning to minimise load oscillation.

Soft Servo

Any axis (also external) can be switched to soft servo mode, which means that it will adopt a spring-like behaviour.

2.4 Safety

Many safety concepts reside in hardware and are not within the scope of this document. However, some important software contributions will be mentioned:

Reduced Speed

In the reduced speed mode, the controller limits all parts of the robot body, the TCP and one user defined point (attached to the upper arm) to 250 mm/s (can be set lower). This limitation also works in joint system motion.

Motion Supervision

See *Motion Control*.

Authorisation

It is possible to limit the access to certain commands by assigning different passwords to four different user levels (operator, service, programmer, service & programmer). It is possible to define the commands available at the different levels.

Limited modpos

It is possible to limit the allowed distance/rotation when modifying positions.

2.5 I/O System

Elementary I/O

Robust and fast distributed system built on CAN/DeviceNet with the following features:

- Named signals and actions with mapping to physical signal (“gripper close” instead of “set output 1”).
- Flexible cross connections.
- Up to 512 signals available (one signal = single DI or DO, group of DI or DO, AI or AO).
- Grouping of signals to form integer values.
- Sophisticated error handling.
- Selectable “trust level” (i.e. what action to take when a unit is “lost”).
- Program controlled enabling/disabling of I/O units.
- Scaling of analog signals.
- Filtering.
- Polarity definition.
- Pulsing.
- TCP-proportional analog signal.
- Programmable delays.
- Simulated I/O (for forming cross connections or logical conditions without need the for physical hardware).
- Accurate coordination with motion.

Serial I/O

XON/XOFF or SLIP.

Memory I/O

RAM disk and floppy disk.

3 BaseWare Options

3.1 Advanced Functions 3.2

Includes functions making the following possible:

- Information transfer via serial channels or files.
- Setting an output at a specific position.
- Executing a routine at a specific position.
- Defining forbidden areas within the robot´s working space.
- Automatic setting of output when the robot is in a user-defined area.
- Robot motion in an error handler or trap routine, e.g. during automatic error handling.
- Cross connections with logical conditions.
- Interrupts from analog input or output signals.

Transferring information via serial channels

Data in the form of character strings, numeric values or binary information can be transferred between the robot and other peripheral equipment, e.g. a PC, bar code reader, or another robot. Information is transferred via an RS232 or RS485 serial channel.

Examples of applications:

- Printout of production statistics on a printer connected to the robot.
- Reading part numbers from a bar code reader with a serial interface.
- Transferring data between the robot and a PC.

The transfer is controlled entirely from the robot’s work program. When it is required to control the transfer from a PC, use the option *RAP Communication* or *FactoryWare Interface*.

Data transfer via files

Data in the form of character strings, numerical values or binary information can be written to or read from files on a diskette or other type of mass storage/memory.

Examples of applications:

- Storing production statistics on a diskette or ramdisk. This information can then be read and processed by an ordinary PC.
- The robot’s production is controlled by a file. This file may have been created in a PC, stored on a diskette, and read by the robot at a later time.

Fixed position output

The value of an output (digital, analog or a group of digitals) can be ordered to change at a certain distance before or after a programmed position. The output will then change at the same place every time, irrespective of the robot’s speed.

Consideration can also be given to time delays in the process equipment. By specifying this time delay (max. 500 ms), the output is set at the corresponding time before the robot reaches the specified position.

The distance can also be specified as a certain time before the programmed position. This time must be within the deceleration time when approaching that position.

Examples of applications:

- Handling press work, to provide a safe signalling system between the robot and the press, which will reduce cycle times. Just as the robot leaves the press, an output is set that starts the press.
- Starting and finishing process equipment. When using this function, the start will always occur at the same position irrespective of the speed. For gluing and sealing, see *GlueWare*.

Fixed position procedure call

A procedure call can be carried out when the robot passes the middle of a corner zone. The position will remain the same, irrespective of the robot’s speed.

Example of application:

- In the press example above, it may be necessary to check a number of logical conditions before setting the output that starts the press. A procedure which takes care of the complete press start operation is called at a position just outside the press.

World Zones

A spherical, cylindrical or cubical volume can be defined within the working space. When the robot reaches this volume it will either set an output or stop with the error message “Outside working range”, both during program execution and when the robot is jogged into this area. The areas, which are defined in the world coordinate system, can be automatically activated at start-up or activated/deactivated from within the program.

Examples of applications:

- A volume is defining the home position of the robot.
  When the robot is started from a PLC, the PLC will check that the robot is inside the home volume, i.e. the corresponding output is set.
- The volume is defining where peripheral equipment is located within the working space of the robot.
  This ensures that the robot cannot be moved into this volume.
- A robot is working inside a box.
  By defining the outside of the box as a forbidden area, the robot cannot run into the walls of the box.
- Handshaking between two robots both working in the same working space.
  When one of the robots enters the common working space, it sets an output and after that enters only when the corresponding output from the other robot is reset.

Movements in interrupt routines and error handlers

This function makes it possible to temporarily interrupt a movement which is in progress and then start a new movement which is independent of the first one. The robot stores information about the original movement path which allows it to be resumed later.

Examples of applications:

- Cleaning the welding gun when a welding fault occurs. When a welding fault occurs, there is normally a jump to the program’s error handler. The welding movement in progress can be stored and the robot is ordered to the cleaning position so that the nozzle can be cleaned. The welding process can then be restarted, with the correct parameters, at the position where the welding fault occurred. This is all automatic, without any need to call the operator. (This requires options *ArcWare* or *ArcWare Plus*.)
- Via an input, the robot can be ordered to interrupt program execution and go to a service position, for example. When program execution is later restarted (manually or automatically) the robot resumes the interrupted movement.

Cross-connections with logical conditions

Logical conditions for digital input and output signals can be defined in the robot’s system parameters using AND, OR and NOT. Functionality similar to that of a PLC can be obtained in this way.

Example:

- Output 1 = Input 2 AND Output 5.
- Input 3 = Output 7 OR NOT Output 8.

Examples of applications:

- Program execution to be interrupted when both inputs 3 and 4 become high.
- A register is to be incremented when input 5 is set, but only when output 5=1 and input 3=0.

Interrupts from analog input or output signals

An interrupt can be generated if an analog input (or output) signal falls within or outside a specified interval.

RAPID instructions and functions included in this option

Open	Opens a file or serial channel
Close	Closes a file or serial channel
Write	Writes to a character-based file or serial channel
WriteBin	Writes to a binary file or serial channel
WriteStrBin	Writes a string to a binary serial channel
ReadNum	Reads a number from a file or serial channel
ReadStr	Reads a string from a file or serial channel
ReadBin	Reads from a binary file or serial channel
Rewind	Rewind file position
WriteAnyBin	Write data to a binary serial channel or file
ReadAnyBin	Read data from a binary serial channel or file
ReadStrBin	Read a string from a binary serial channel or file
ClearIOBuff	Clear input buffer of a serial channel
WZBoxDef	Define a box shaped world zone
WZCylDef	Define a cylinder shaped world zone
WZLimSup	Activate world zone limit supervision
WZSphDef	Define a sphere shaped world zone
WZDOSet	Activate world zone to set digital output
WZDisable	Deactivate world zone supervision
WZEnable	Activate world zone supervision
WZFree	Erase world zone supervision
StorePath	Stores the path when an interrupt or error occurs
RestoPath	Restores the path after an interrupt/error
TriggC	Position fix output/interrupt during circular movement
TriggL	Position fix output/interrupt during linear movement
TriggJ	Position fix output/interrupt during joint movement
TriggIO	Definition of trigger conditions for one output
TriggEquip	Definition of trigger conditions for process equipment with time delay
TriggInt	Definition of trigger conditions for an interrupt
MoveCSync	Position fix procedure call during circular movement
MoveLSync	Position fix procedure call during linear movement
MoveJSync	Position fix procedure call during join movement
ISignalAI	Interrupts from analog input signal
ISignalAO	Interrupts from analog output signal

3.2 Advanced Motion 3.2

Contains functions that offer the following possibilities:

- Resetting the work area for an axis.
- Independent movements.
- Contour tracking.
- Coordinated motion with external manipulators.

Resetting the work area for an axis

The current position of a rotating axis can be adjusted a number of complete turns without having to make any movements.

Examples of applications:

- When polishing, a large work area is sometimes needed on the robot axis 4 or axis 6 in order to be able to carry out final polishing without stopping. Assume that the axis has rotated 3 turns, for example. It can now be reset using this function, without having to physically rotate it back again. Obviously this will reduce cycle times.
- When arc welding, the work object is often fitted to a rotating external axis. If this axis is rotated more than one turn during welding, the cycle time can be reduced because it is not necessary to rotate the axis back between welding cycles.

Coordinated motion with multi-axis manipulators

Coordinated motion with multi-axis manipulators or robot carriers (gantries) requires the Advanced Motion option. Note that simultaneous coordination with several single axis manipulators, e.g. track motion and workpiece manipulator, does not require Advanced Motion.

Note! There is a built-in general method for defining the geometry for a manipulator comprising two rotating axes (see User’s Guide, *Calibration*). For other types of manipulators/robot carriers, comprising up to six linear and/or rotating axes, a special configuration file is needed. Please contact your nearest ABB Flexible Automation Centre.

Contour tracking

Path corrections can be made in the path coordinate system. These corrections will take effect immediately, also during movement between two positions. The path corrections must be entered from within the program. An interrupt or multitasking is therefore required to activate the correction during motion.

Example of application:

- A sensor is used to define the robot input for path correction during motion. The input can be defined via an analog input, a serial channel or similar. Multitasking or interrupts are used to read this information at specific intervals. Based on the input value, the path can then be adjusted.

Independent movements

A linear or rotating axis can be run independently of the other axes in the robot system. The independent movement can be programmed as an absolute or relative position. A continuous movement with a specific speed can also be programmed.

Examples of applications:

- A robot is working with two different stations (external axes). First, a work object located at station 1 is welded. When this operation is completed, station 1 is moved to a position where it is easy to change the work object and at the same time the robot welds the work object at station 2. Station 1 is moved independently of the robot's movement, which simplifies programming and reduces the cycle time.
- The work object is located on an external axis that rotates continuously at a constant speed. In the mean time, the robot sprays plasma, for example, on the work object. When this is finished the work area is reset for the external axis in order to shorten the cycle time.

Friction Compensation

During low speed (10-100 mm/s) cutting of fine profiles, in particular small circles, a friction effect, typically in the form of approximately 0.5 mm “bumps”, can be noted. Advanced Motion offers a possibility of compensating for these frictional effects. Typically a 0.5 mm “bump” can be reduced to about 0.1 mm. This, however, requires careful tuning of the friction level (see User's Guide for tuning procedure). Note that even with careful tuning, there is no guarantee that “perfect” paths can always be generated.

For the IRB 6400 family of robots, no significant effects can be expected by applying Friction Compensation.

External Drive System

With Advanced Motion, the possibility to connect off-the-shelf standard drive systems for controlling external axes is available. This can be of interest, for example, when the power of the available S4C drives does not match the requirements.

There are two alternatives:

- The Atlas Copco Controls´ stand alone servo amplifier DMC.
- The Atlas Copco Controls´ FBU (Field Bus Unit) that can handle up to three external drive units per FBU unit.
  These can be connected to analog outputs (+/- 10 V) or a field bus.
  The drive board can thus be of virtually any make and type.

For further information about DMC and FBU, please contact Atlas Copco Controls.

NOTE! The DMC/FBU must be equipped with Atlas Copco Controls option C.

RAPID instructions and functions included in this option

IndReset	Resetting the work area for an axis
IndAMove	Running an axis independently to an absolute position
IndDMove	Running an axis independently for a specified distance
IndRMove	Running an axis independently to a position within one revolution, without taking into consideration the number of turns the axis had rotated earlier
IndCMove	Running an axis continuously in independent mode
IndInpos	Checking whether or not an independent axis has reached the programmed position
IndSpeed	Checking whether or not an independent axis has reached the programmed speed
CorrCon	Activating path correction
CorrWrite	Changing path correction
CorrRead	Read current path correction
CorrDiscon	Deactivating path correction
CorrClear	Removes all correction generators

3.3 Multitasking

Up to 10 programs (tasks) can be executed in parallel with the normal robot program.

- These additional tasks start automatically at power on and will continue until the robot is powered off, i.e. even when the main process has been stopped and in manual mode.
- They are programmed using standard RAPID instructions, except for motion instructions.
- They can be programmed to carry out various activities in manual or automatic mode, and depending on whether or not the main process is running.
- Communication between tasks is carried out via I/O or global data.
- Priorities can be set between the processes.

Examples of applications:

- The robot is continuously monitoring certain signals even when the robot program has stopped, thus taking over the job traditionally allocated to a PLC.
- An operator dialogue is required at the same time as the robot is doing, for example, welding. By putting this operator dialogue into a background task, the operator can specify input data for the next work cycle without having to stop the robot.
- The robot is controlling a piece of external equipment in parallel with the normal program execution.

Performance

When the various processes are programmed in the correct way, no performance problems will normally occur:

- When the priorities for the various processes are correctly set, the normal program execution of the robot will not be affected.
- Because monitoring is implemented via interrupts (instead of checking conditions at regular intervals), processor time is required only when something actually happens.
- All input and output signals are accessible for each process.

Note that the response time of Multitasking does not match that of a PLC. Multitasking is primary intended for less demanding tasks.

The available program memory can be divided up arbitrarily between the processes. However, each process in addition to the main process will reduce the total memory, see section 5.1.

3.4 FactoryWare Interface 3.2

This option enables the robot system to communicate with a PC using RobComm 3.0 or later versions (see *FactoryWare*). The FactoryWare Interface 3.2 serves as a run-time license for RobComm, i.e. the PC does not require any license protection when executing a RobComm based application. However, when developing such an application, a hardware lock and password are needed in the PC (design time license).

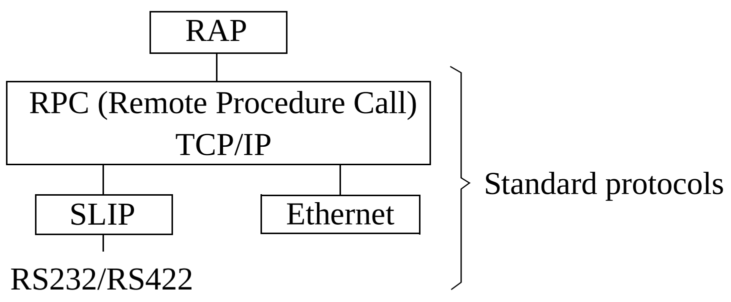
Older versions of RobComm will require RAP Communication in the robot and license protection in the PC (hardware lock and password for design and run-time, or only password for only run-time).

This option will also work with RobView 3.2/1 or DDE Server 2.3/1 (or later versions). Older versions work only with RAP Communication. In all cases RobView and DDE Server will require the hardware lock and password.

The Factory Ware Interface 3.2 includes the Robot Application Protocol (RAP), based on MMS functionality. The Robot Application Protocol is used for computer communication. The following functions are supported:

- Start and stop program execution
- Transfer programs to/from the robot
- Transfer system parameters to/from the robot
- Transfer files to/from the robot
- Read the robot status
- Read and write data
- Read and write output signals
- Read input signals
- Read error messages
- Change robot mode
- Read logs

RAP communication is available both for serial links and network, as illustrated by the figure below.



Examples of applications:

- Production is controlled from a superior computer. Information about the robot status is displayed by the computer. Program execution is started and stopped from the computer, etc.
- Transferring programs and parameters between the robot and a PC. When many different programs are used in the robot, the computer helps in keeping track of them and by doing back-ups.
- Programs can be transferred to the robot's ramdisk at the same time as the robot executes its normal program. When execution of this program has finished, the new program can be read very quickly from the ramdisk and program execution can continue. In this way a large number of programs can be handled and the robot's memory does not have to be so big.

RAPID instruction included in this option

SCWrite	Sends a message to the computer (using RAP)

3.5 RAP Communication 3.2

This option is required for all communication with a superior computer, where none of the FactoryWare products RobComm, RobView, or DDE Server, are used. It includes the same functionality described for the option Factory Ware Interface 3.2.

It also works for the FactoryWare products. For RobView and DDE Server, there is no difference from the FactoryWare Interface (except that the price is higher). For RobComm, in this case a license protection requirement in the PC is added.

Note that both FactoryWare Interface and RAP Communication can be installed simultaneously.

3.6 Ethernet Services 3.2

NFS 3.2

Information in mass storage, e.g. the hard disk in a PC, can be read directly from the robot using the NFS protocol. The robot control program can also be booted via Ethernet instead of using diskettes. This requires Ethernet hardware in the robot.

FTP 3.2

This option includes the same functionality as described for Ethernet Services NFS exept that the protocol used for remote mounted disc functionality is FTP.

The aspect of authorization differs between NFS and FTP.

Examples of applications:

- All programs for the robot are stored in the PC. When a new part is to be produced, i.e. a new program is to be loaded, the program can be read directly from the hard disk of the PC. This is done by a manual command from the teach pendant or an instruction in the program. If the option RAP Communication or FactoryWare Interface is used, it can also be done by a command from the PC (without using the ramdisk as intermediate storage).
- Several robots are connected to a PC via Ethernet. The control program and the user programs for all the robots are stored on the PC. A software update or a program backup can easily be executed from the PC.

3.7 Profibus DP 3.2

With a Profibus-DP Master/Slave board (DSQC368) in the S4C controller it is possible to connect many sets of in- and output I/O units via the serial Profibus-DP field bus net, and all the Profibus-DP signals are handled and addressed in the same way as any other distributed I/O signal.

The maximum number of I/O units that can be defined in the S4C system is described in User's Guide Baseware chapter I/O data specification. As I/O units counts all DP-slave units connected to the S4C DP-master, the DP-slave, simulated I/O units and other I/O units connected to other S4C fieldbuses.

It is possible to connect digital and/or analog in- and output I/O units on the DSQC368 master bus. All I/O units must fulfil the DIN 19245 Part 3 Profibus Specification - DP and must be certified by PNO[1].

1. Profibus Nutzer Organization

3.8 Interbus-S 3.2

With an InterBus-S generation 4 Master/Slave board (DSQC344) in the S4C robot controller, it is possible to connect many sets of input/output modules via the serial InterBus-S field bus net.

The robot controller handles and addresses the InterBus-S I/O signals in the same way it manages any other S4C distributed I/O signals.

It should be noted that this is a supplementary manual to the other robot manuals. Detailed description of the InterBus-S and different I/O units will be found in the documents from e.g. Phoenix Contact & Co.

3.9 Load Identification and Collision Detection 3.2 (LidCode)

This option is only available for the IRB 6400 family of robots and for external manipulators IRBP-L and IRBP-K.

LidCode contains two very useful features:

Load Identification

To manually calculate or measure the load parameters accurately can be very difficult and time consuming. Operating a robot with inaccurate load parameters can have a detrimental influence on cycle time and path accuracy.

With LidCode, the robot can carry out accurate identification of the complete load data (mass, centre of gravity, and three inertia components). If applicable, tool load and payload are handled separately.

The identification procedure consists of limited predefined movements of axes 3, 5 and 6 during approximately three minutes. The starting point of the identification motion pattern can be chosen by the user so that collisions are avoided.

The accuracy achieved is normally better than 5%.

Collision Detection

Abnormal torque levels on any robot axis (not external axes) are detected and will cause the robot to stop quickly and thereafter back off to relieve forces between the robot and environment.

Tuning is normally not required, but the sensitivity can be changed from Rapid or manually (the supervision can even be switched off completely). This may be necessary when strong process forces are acting on the robot.

The sensitivity (with default tuning) is comparable to the mechanical alternative (mechanical clutch) and in most cases much better. In addition, LidCode has the advantages of no added stick-out and weight, no need for connection to the e-stop circuit, no wear, the automatic backing off after collision and, finally, the adjustable tuning.

Two system outputs reflect the activation and the trig status of the function.

RAPID instructions included in this option

MotionSup	Changing the sensitivity of the collision detection or activating/deactivating the function.
ParIdRobValid	Checking that identification is available for a specific robot type.
ParIdPosValid	Checking that the current position is OK for identification.
LoadId	Performing identification.
MechUnitLoad	Defenition of payload for external mechanical units.

3.10 ScreenViewer 3.2

This option adds a user window to display user defined screens with advanced display functions. The user window can be displayed at any time, regardless of the execution state of the RAPID programs.

User defined screens

The user defined screens are composed of:

- A fixed background with a size of 12 lines of 40 characters each. These characters can be ASCII and/or horizontal or vertical strokes (for underlining, separating or framing).
- 1 to 5 function keys.
- 1 to 4 pop-up menus containing from 1 to 10 choices.
- 1 to 30 display and input fields defined by:
  - Their position and size.
  - Their type (display, input).
  - Their display format (integer, decimal, binary, hexadecimal, text).
  - A possible boundary with minimum and maximum limits.

Example of a user defined screen. The ### represent the fields.

```
 SpotTim                 File                  View
-----------------------------------------------------
 Program number: ###               Heat stepper: ###
                                    interpolated: ##
                  | CURENT (A)        |
 PHASES     |  T  | START   | END     | Tolerance: ###%
 SQUEEZE    | ##  |         |         | Force: ###daN
 PREHEAT    | ##  | ####    |         | Forge: ###daN
 COOLING    | ##  |         | ####    |
 ## HEAT    | ##  | ####    |         | Fire chck: ###
 COLD       | ##  |         |         |
 LASTCOLD   | ##  |         |         | Err allow: ###%
 POSTHEAT   | ##  | ####    | ####    | Numb err: ###
 HOLD       | ##  |         |
-----------------------------------------------------
   Next            Prev.    (Copy)          Valid
```

Advanced Display functions

The user defined screens run independently of the RAPID programs.

Some events occur on a screen (new screen displayed, menu choice selected, function key pressed, field modified, ...). A list of user screen commands can be associated with any of these events, then when the event occurs, the command list will be executed.

A screen event can occur

- When a new screen is displayed (to initialize the screen contents).
- After a chosen interval (to refresh a screen).
- When a menu choice or a function key is selected (to execute a specific action, or change the screen).
- When a new value is entered in a field, or when a new field is selected (to execute some specific action).

The commands that can be executed on screen events are

- Reading/writing RAPID or I/O data.
- Reading/writing fields contents.
- Arithmetical (+, -, /, *, div) or logical (AND, OR, NOT, XOR) operations on the data read.
- Comparing data read (=, <, >) and carrying out a command or not, depending on the comparison result.
- Displaying a different screen.

Capacities

The user screens can be grouped in a screen package file under a specific name. Up to 8 packages can be loaded at the same time.

A certain amount of memory (approx. 50 kbytes) is reserved for loading these screen packages.

- The screen package to be displayed is selected using the far right hand menu “View” (which shows a list of the screen packages installed).

3.11 Conveyor Tracking 3.2

Conveyor Tracking (also called Line Tracking) is the function whereby the robot follows a work object which is mounted on a moving conveyor. While tracking the conveyor, the programmed TCP speed relative to the work object will be maintained, even when the conveyor speed is changing slowly.

Note that hardware components for measuring the conveyor position are also necessary for this function. Please refer to the Product Specification for your robot.

Conveyor Tracking provides the following features:

- A conveyor can be defined as either linear or circular.
- It is possible to have two conveyors connected simultaneously and to switch between tracking the one or the other.
- Up to 254 objects can reside in an object queue which can be manipulated by RAPID instructions.
- It is possible to define a start window in which an object must be before tracking can start.
- A maximum tracking distance may be specified.
- If the robot is mounted on a parallel track motion, then the system can be configured such that the track will follow the conveyor and maintain the relative position to the conveyor.
- Tracking of a conveyor can be activated “on the fly”, i.e. it is not necessary to stop in a fine point.

Performance

At 150 mm/s constant conveyor speed, the TCP will stay within +/-2 mm of the path as seen with no conveyor motion. When the robot is stationary relative to the conveyor, the TCP will remain within 0.7 mm of the intended position.

These values are valid as long as the robot is within its dynamic limits with the added conveyor motion and they require accurate conveyor calibration.

RAPID instructions included in this option

WaitWObj	Connects to a work object in the start window
DropWObj	Disconnects from the current object

3.12 I/O Plus 3.2

I/O Plus enables the S4C to use non-ABB I/O units. The following units are supported:

- Wago modules with DeviceNet fieldbus coupler, item 750-306 revision 3.
- Lutze IP67 module DIOPLEX-LS-DN 16E 744-215 revision 2 (16 digital input signals).
- Lutze IP67 module DIOPLEX-LS-DN 8E/8A 744-221 revision 1 (8 digital input signals and 8 digital output signals).

For more information on any of these untis, please contact the supplier.

The communication between these units and S4C has been verified (this does not, however, guarantee the internal functionality and quality of the units). Configuration data for the units is included.

In I/O Plus there is also support for a so-called “Welder”. This is a project specific spot welding timer, and is not intended for general use.

In addition to the above units, the I/O Plus option also opens up the possibility to use other digital I/O units that conform with the DeviceNet specification. ABB Robotics Products AB does not assume any responsibility for the functionality or quality of such units. The user must provide the appropriate configuration data.

4 ProcessWare

4.1 ArcWare 3.2

ArcWare comprises a large number of dedicated arc welding functions, which make the robot well suited for arc welding. It is a simple yet powerful program since both the positioning of the robot and the process control and monitoring are handled in one and the same instruction.

I/O signals, timing sequences and weld error actions can be easily configured to meet the requirements of a specific installation.

ArcWare functions

A few examples of some useful functions are given below.

Adaptation to different equipment

The robot can handle different types of weld controllers and other welding equipment. Normally communication with the welding controller uses parallel signals but a serial interface is also available.

Advanced process control

Voltage, wire feed rate, and other process data can be controlled individually for each weld or part of a weld. The process data can be changed at the start and finish of a welding process in such a way that the best process result is achieved.

Testing the program

When testing a program, welding, weaving or weld guiding can all be blocked. This provides a way of testing the robot program without having the welding equipment connected.

Automatic weld retry

A function that can be configured to order one or more automatic weld retries after a process fault.

Weaving

The robot can implement a number of different weaving patterns up to 10 Hz depending on robot type. These can be used to fill the weld properly and in the best possible way. Weaving movement can also be ordered at the start of the weld in order to facilitate the initial striking of the arc.

Wire burnback and rollback

These are functions used to prevent the welding wire sticking to the work object.

Fine adjustment during program execution

The welding speed, wire feed rate, voltage and weaving can all be adjusted whilst welding is in progress. This makes trimming of the process much easier because the result can be seen immediately on the current weld. This can be done in both manual and automatic mode.

Weld Guiding

Weld guiding can be implemented using a number of different types of sensors. Please contact your nearest ABB Flexible Automation Centre for more information.

Interface signals

The following process signals are, if installed, handled automatically by ArcWare. The robot can also support dedicated signals for workpiece manipulators and sensors.

Digital outputs	**Description**
Power on/off	Turns weld on or off
Gas on/off	Turns gas on or off
Wire feed on/off	Turns wire feed on or off
Wire feed direction	Feeds wire forward/backward
Weld error	Weld error
Error information	Digital outputs for error identification
Weld program number	Parallel port for selection of program number, or 3-bit pulse port for selection of program number, or Serial CAN/Devicenet communication

Digital inputs	**Description**
Arc OK	Arc established; starts weld motion
Voltage OK	Weld voltage supervision
Current OK	Weld current supervision
Water OK	Water supply supervision
Gas OK	Gas supply supervision
Wire feed OK	Wire supply supervision
Manual wire feed	Manual command for wire feed
Weld inhibit	Blocks the welding process
Weave inhibit	Blocks the weaving process
Stop process	Stops/inhibits execution of arc welding instructions
Wirestick error	Wirestick supervision
Supervision inhibit	Program execution without supervision
Torch collision	Torch collision supervision

Analog outputs	**Description**
Voltage	Weld voltage
Wire feed	Velocity of wire feed
Current	Weld current
Voltage adjustment	Voltage synergic line amplification
Current adjustment	Current synergic line amplification

Analog inputs (cont.)	**Description (cont.)**
Voltage	Weld voltage measurement for monitoring and supervision
Current	Weld current measurement for monitoring and supervision

RAPID instructions included in this option

ArcL	Arc welding with linear movement
ArcC	Arc welding with circular movement

4.2 ArcWare Plus 3.2

ArcWare Plus contains the following functionality:

- ArcWare, see previous chapter.
- Arc data monitoring.
  Arc data monitoring with adapted RAPID instructions for process supervision. The function predicts weld errors.
- Contour tracking.
  Path corrections can be made in the path coordinate system. These corrections will take effect immediately, also during movement between two positions. The path corrections must be entered from within the program. An interrupt or multitasking is therefore required to activate the correction during motion.

  Example of application:

  A sensor is used to define the robot input for path correction during motion. The input can be defined via an analog input, a serial channel or similar. Multitasking or interrupts are used to read this information at specific intervals. Based on the input value, the path can then be adjusted.
- Adaptive process control.
  Adaptive process control for LaserTrak and Serial Weld Guide systems. The tool provides the robot system with changes in the shape of the seam. These values can be used to adapt the process parameters to the current shape.

RAPID instructions and functions included in this option

ArcKill	Aborts the process and is intended to be used in error handlers
ArcRefresh	Updates the weld references to new values
CorrCon	Activating path correction
CorrWrite	Changing path correction
CorrRead	Read current path correction
CorrDiscon	Deactivating path correction
CorrClear	Removes all correction generators
SpcCon	Activates statistical process supervision
SpcWrite	Provides the controller with values for statistical process supervision
SpcDump	Dumps statistical process supervision data to a file or on a serial channel
SpcRead	Reads statistical process supervision information
SpcDiscon	Deactivates statistical process supervision

4.3 SpotWare 3.2

SpotWare comprises a large number of dedicated spot welding functions which make the robot well suited for spot welding. It is a simple yet powerful program since both the positioning of the robot and the process control and monitoring are handled in one and the same instruction.

Cycle times can be shortened by means of closing the spot welding gun in advance, together with the fact that movement can commence immediately after a spot weld is completed. The robot’s self-optimising motion control, which results in fast acceleration and a quick approach to the spot weld, also contributes to making cycle times shorter.

I/O signals, timing sequences and weld error actions can be easily configured to meet the requirements of a specific installation.

SpotWare functions

A few examples of some useful functions are given below.

Adaptation to different welding guns

Gun control (opening and closing) can be programmed freely to suit most types of guns, irrespective of the signal interface.

Adaptation to different weld timers

The robot can handle different types of weld timers. Normally communication with the weld timer uses parallel signals but a serial interface is also available for some types of weld timers.

Continuous supervision of the welding equipment

If the option Multitasking is added, supervision can be implemented irrespective of the spotweld instruction. For example, it is possible to monitor peripheral equipment even when program execution has been stopped.

Closing the gun

It is possible to start closing the spot welding gun before reaching the programmed point. By defining a time of closure, the gun can be closed correctly regardless of the speed of the robot. The cycle time is optimised when the gun is just about to close at the instant when the robot reaches the programmed point.

Constant squeeze time

Welding can be started directly as the gun closes, i.e. without waiting for the robot to reach its final position. This gives a constant time between gun closure and weld start.

Customised Move enable

The movement after a completed spot weld can be configured to start either on a user defined input signal or a delay time after weld ready.

Immediate move after Move enable

The robot moves immediately when enable is given. This is achieved by preparing the next action while waiting for the current weld to be completed.

Gun control

The system supports double guns, small and large strokes and gun pressure control. Several guns can be controlled in the same program.

Testing the program

The program can be run one instruction at a time, both forwards and backwards. When it is run backwards, only motion instructions, together with an inverted gun movement, are executed. The program can also be test run without connecting a weld timer or spot welding gun. This makes the program easier to test.

Rewelds

A function that can be configured to order one or more automatic rewelds or, when the program is restarted after an error, a manual reweld.

Process error routines

In the event of a process error, installation-specific routines, such as go-to-service position, can be ordered manually. When the appropriate routine has been performed, the weld cycle continues from where it was interrupted.

Manual welding independent of positioning

A spot weld can be ordered manually at the current robot position. This is implemented in a similar way as for program execution, i.e. with gun control and process supervision. It is also possible to order a separate gun control with full supervision.

Interface signals

The following process signals are, if installed, handled automatically by SpotWare.

Digital outputs	Description
start 1	start signal to the weld timer (tip 1)
start 2	start signal to the weld timer (tip 2)
close tip 1	close gun (tip 1)
close tip 2	close gun (tip 2)
work select	select work or retract stroke of the gun
program parity	weld program parity bit
reset fault	reset the weld timer
process error	operator request is set when an error occurs
current enable	weld inhibit to the weld timer
p2 request	set pressure 2
p3 request	set pressure 3
p4 request	set pressure 4
weld power	activate the weld power unit contactor
water start	activate water cooling

manual close gun	close gun manually
manual open gun	open gun manually
manual run process	run a complete spot weld
manual skip process	skip the ongoing action
manual new data	send data for the manual actions
process run	process is executed
inhibit move	block spot welding movement
weld error	weld ready timeout

Digital output groups	**Description**
program no.	weld program number
initiate	used for several weld timers

Digital inputs	**Description**
weld ready 1	weld, started with start 1, is finished
weld ready 2	weld, started with start 2, is finished
tip 1 open	the gun (tip 1) is open
tip 2 open	the gun (tip 2) is open
tip 1 retract	the gun (tip 1) opened to retract stroke
tip 2 retract	the gun (tip 2) opened to retract stroke
p1 OK	pressure 1 is reached
p2 OK	pressure 2 is reached
p3 OK	pressure 3 is reached
p4 OK	pressure 4 is reached
timer OK	the weld timer is ready to weld
flow OK	no problem with the water supply
temp OK	no over-temperature
current OK	the weld current is within permissible tolerances

User defined routines

The following routines are predefined but can be adapted to suit the current installation.

Routine	**Description**
preweld supervision	supervision to be done before welding
postweld supervision	supervision to be done after welding
init supervision	supervision to be done for a warm start
motor on action	action to be taken for Motors On
motor off action	action to be taken for Motors Off
process OK action	action to be taken for welding sensor OK
process error action	action to be taken for a process error
current enable action	action to be taken for current enable
current disable action	action to be taken for current disable
close gun	definition of gun closing
open gun	definition of gun opening
set pressure	definition of gun pressure setting
service close gun	error handling when gun pressure is not achieved
service open gun	error handling at timeout for gun opening
service weld fault	error handling at timeout for weld-ready signal

The option *Advanced functions* is included.

RAPID instructions included in this option

SpotL	Spot welding with linear movement

4.4 SpotWare Plus 3.2

In addition to the SpotWare functionality the robot can weld with up to four stationary welding guns simultaneously.

RAPID instructions included in this option

SpotML	Multiple spot welding with linear movement.

4.5 GlueWare 3.2

GlueWare comprises a large number of dedicated gluing functions which make the robot well suited for gluing and sealing. It is a simple yet powerful program since both the positioning of the robot and the process control are handled in one and the same instruction.

I/O signals and timing sequences can be easily configured to meet the requirements of a specific installation.

GlueWare functions

A few examples of some useful functions are given below.

Adaptation to different gluing guns

Both on/off guns and proportional guns can be handled. Furthermore, time delays can be specified for the gluing guns in order to obtain the correct thickness of glue or sealing compound and application at the specified time.

Two gluing guns

One or two gluing guns can be controlled. Up to two analog outputs can be controlled for each gun.

Velocity independent glue string thickness

The thickness of the glue string can be made independent on the robot’s velocity by controlling the gluing gun with a signal that reflects the robot’s velocity. When the robot velocity is reduced, the flow of glue will be automatically reduced. The robot can compensate for a gun delay of up to 500 ms, thanks to a proactive signal.

Flow change at a specific position

Flow changes (incl. start and stop) can be put into the programmed path, also where there are no programmed positions. These positions will remain fixed even when the velocity is changed, which makes the programming much simpler.

Global flow changes

The glue flow can be changed for the whole program just by changing one value.

Program testing without glue

Gluing can be temporarily blocked in order to be able to test the robot’s movements without any glue flow.

Interface signals

When installed, the following process signals are handled automatically by GlueWare.

Analog outputs	**Description**
gun1 flow1	Glue flow reference gun 1
gun1 flow 2	Glue flow reference gun 1
gun2 flow1	Glue flow reference gun 2
gun2 flow 2	Glue flow reference gun 2

Digital outputs	**Description**
gun 1 on/off	glue off/on gun1
gun 2 on/off	glue off/on gun 2
overspeed error	the calculated value of an analog output signal is greater than its logical max. value
process error	error during gluing

User defined routines

The following routines are predefined but can be adapted to suit the current installation.

Routine	**Description**
preglue actions	activity to be carried out in the beginning of the glue string
postglue actions	activity to be carried out at the end of the glue string
power on action	activity to be carried out at power-on
restart action	activity to be carried out at program start
stop action	activity to be carried out at program stop
emergency stop action	activity to be carried out in the event of an emergency stop or other safeguarded space stop

The option *Advanced functions* is included.

RAPID instructions included in this option

GlueL	Gluing with linear movement
GlueC	Gluing with circular movement

4.6 DispenseWare 3.2

The DispenseWare package provides support for different types of dispensing processes such as gluing and sealing.

The DispenseWare application provides fast and accurate positioning combined with a flexible process control.

Communication with the dispensing equipment is carried out by means of digital and analog outputs.

DispenseWare is a package that can be extensively customized. The intention is that the user adapts some user data and routines to suit a specific dispensing equipment and the environmental situation.

Dispensing features

The DispenseWare package contains the following features:

- Fast and accurate positioning.
- Handling of on/off guns as well as proportional guns.
- Speed proportional or constant analog outputs.
- Up to five different guns can be handled simultaneously, controlled by 1 - 5 digital output signals (for gun on/off control) and 1 - 2 analog output signals (for flow control).
- Four different gun equipment, each controlled by 1 - 5 digital output signals and 1 - 2 analog output signals, can be handled in the same program.
- Possibility to use different anticipated times for the digital and analog signals.
- Possibility to use equipment delay compensation for the TCP speed proportional analog signals.
- Global or local flow rate correction factors.
- Dispensing instructions for both linear and circular paths.
- Dispensing in wet or dry mode.
- Wide opportunities of customizing the functionality to adapt to different types of dispensing equipment.

4.7 PaintWare 3.2

PaintWare comprises a large number of dedicated painting functions which make the robot well suited for painting and coating operations. It is powerful, yet simple since both the robot positioning and the paint events are handled in one and the same instruction. All phases of the paint process are controlled, such as start, change, and stop painting, due to trig plane events.

The necessary structures for paint process data are predefined and organised as BrushData and BrushTables.

PaintWare is only avaliable with painting robots.

PaintWare functionality

When painting, the fluid and air flow through the spray gun is controlled to suit the part being coated and the thickness requirements. These process parameters are changed along the path to achieve optimum control of the paint equipment along an entire path. The paint process is monitored continuously.

A set of gun process parameters is called a Brush and it is possible to select different brushes during a linear paint instruction. A brush can contain up to five parameters:

Paint	The Paint flow reference.
Atom_air	The Atomising air reference.
Fan_air	The Fan air reference.
Voltage	The Electrostatic voltage reference.
Rotation	The Rotation speed reference (for rotational applicators).

The five parameters may go directly to analog outputs controlling the spray gun in an open loop system, or may go to dedicated I/O boards for closed loop gun control (IPS).

The Brushes are set up as an array, called a BrushTable. A specific BrushTable is selected with the instruction UseBrushTab.

The changing of brushes along a path is done using events in the PaintL instruction. The event data describes how a trig plane is located in the active object coordinate system. It also describes which brush to use when the path crosses the plane. Event data is included in all linear paint instructions as optional arguments. A maximum of ten events can be held within one PaintL instruction.

Data types included in this option

BrushData	Data for one brush: flow, atomising air, fan air, etc.
EventData	Data for one event: trig-plane (x, y or z), plane value and brush numberPaintL, PaintC, UseBrushTab,

RAPID instructions included in this option

PaintL	Paint along a straight path w/paint events
PaintC	Paint along a circular path
UseBrushTab	Used to activate (select) a brush-table.
SetBrush	Select a brush from the activated brush-table.

4.8 PalletWare

General

The PalletWare package is a set of Rapid modules and user screens, which perform basic operations related to a palletizing or depalletizing process. These operations include a number of services which can be called from a main program to perform pick and place operations for one or up to five palletizing tasks in parallel. For each such task a number of separate dynamic variables are used to describe and keep track of each on-going pallet operation. The PalletWare package is intended to work with Rapid modules generated from PalletWizard, a PC tool for off-line programming of pallet cycles.

Pallet cycles

Up to five different pallet cycles may be run in parallel, where a pallet cycle is the task to run a complete palletizing job for a pallet, i.e. to pick and place all products, including the pallet itself.

Each pallet cycle includes a number of layer cycles, where each layer cycle is the task to complete one layer with all the parts to be picked and placed in this layer.

Each layer cycle may further be broken down into a number of pick-place cycles, where each pick-place cycle is the task to pick one or several parts and place them on the pallet. Within each pick-place cycle there may be several pick operations, if parts must be picked in many separate operations. Similarly, there may be several place operations in each pick-place cycle.

Each layer may be either an in-feeder layer, where the products, e.g. boxes, are picked from an in-feeder, or a stack layer, where the product, e.g. an empty pallet, is searched and picked from a stack.

If several pallet cycles are run in parallel, then one complete pick-place cycle is always finished before a new one is started in another pallet cycle.

Pallet cell

The pallet cell may include any number of pallet stations, in-feeders and stacks for pallets, tier sheets or slip sheets. All such stations and stacks are defined as regards position, with an individual coordinate system (work object).

The palletizing robot is normally an IRB 6400 or IRB 640 but any robot type may be used. The tool to use may be a mechanical gripper or a tool with suction cups, possibly with separate grip zones for multiple picking and placing. Several different tooldata may be defined and used depending on the product dimensions and number of products.

Products

Any number of different products with different dimensions may be handled and placed in different patterns on the pallet. Each layer must have the same product only, but different layers on a pallet may have different products.

Products may be delivered on one or several in-feeders and placed on one or several different pallets.

For each separate product individual handling speeds and load data are used.

The dimensions and speeds of the products may be changed in run time, thus affecting all pick and place positions.

Movements, approach and retreat positions

All movements are calculated in run time and relative to the different coordinate systems defined for each station. Between stations, e.g. moving from an in-feeder to a pallet station, the robot may be forced to move up to safety height and to retract before moving towards the new station. While moving to the pick or place position, the robot will first move to an approach position and then to a prepick/place position. These horizontal and vertical distances for the approach positions, relative to the pick or place position, may be individually defined per product or station. In addition, the approach direction may be individually defined per pick or place position. These approach data may be changed in run time.

The picking and placing movements and the sequence to search different stacks for empty pallets or tier sheets may be customised if necessary.

User routines

A number of different user routines may be called at certain phases of the pallet cycle. These routines can be used for communication with external equipment, for error checking, for operator messages etc. Such user routines are grouped in three main groups according to when they are called in the pallet cycle. The groups are:

- Cycle routines, connected to the different cycles, i.e. pallet cycle, layer cycle, pick and place cycle. Each such cycle may have its own individual user routine at the beginning, at the middle and at the end of the cycle.
- Station access routines, connected to the different stations. A specific user routine may be called before (station-in routine) and after (station-out) a pick/place on a feeder or pallet station, e.g. to order the next products on the feeder.
- Pick stack routines, connected to stacks. Such routines are called to search and pick a product on the stack.

User screens

The user interacts with the program using menu driven screens on the teach pendant. These screens allow the following functions to be configured:

- Station menu gives access to the robot default parameters, the tool information, the pallet stations, stack stations and feeder station information.
- Product menu gives access to the information related to the different types of product: regular products, empty pallets.
- Cycles menu gives access to the current production status for the different lines.

PalletWare system modules

PalletWare consists of a number of system modules as listed below.

PalletWare Kernel:	PAL_EXE.sys
	PAL_DYN.sys
	PAL_SCR.sys
Generated from PalletWizard:	PAL_CELL.sys
	PAL_CYC.sys

Templates to be completed by the system integrator concerning work object data, tool data, user routines including communication with external equipment etc.:

PAL_USRR.sys

PAL_USRT.sys

Modules and code not included in PalletWare

In addition to the modules listed above, there are some modules which are not included in the PalletWare delivery, but which must be written by the system integrator for specific installations. These are:

- The “main” module, including the main routine. In this routine all logic for working with parallel and simultaneous pallet cycles must be coded by the system integrator, including code required for operator messages, error handling and product changes.
- A system module holding different operator dialogues, which may be called from the main routine in order to change or check pallet cycles or to handle error situations.

System requirements for option PalletWare

- Option ScreenViewer.

5 Memory and Documentation

5.1 Available memory

The available user memory for the different memory options is as follows:

Extended memory	Standard	+8 MB
Total memory	8+8=16 MB (option 402)	8+16=24 MB (option 403)
Program memory without options	2.5 MB (ram disk=0.5 MB)	6.0 MB (ram disk=4.0 MB)

Other software options reduce the available program memory as follows. Options not mentioned have no or small memory consumption (less than 10 kB). All the figures are approximate.

Option	Program memory	Ram disk	Remark
Base system	335 kB	145 kB (225 kB if memory option 403 is chosen)	
Multitasking	80 kB/task (including task 1)		
Advanced Functions	20 kB		
GlueWare/DispenseWare	125 kB	30 kB	Including Advanced Functions
SpotWare	370 kB	55 kB	Including Multitasking with two spotware tasks (one process and one supervision task).
SpotWare Plus	390 kB	75 kB	Including Multitasking with two spotware tasks (one process and one supervision task).
SpotWare Plus	730 kB	75 kB	Including Multitasking with five spotware tasks (four process and one supervision task).
Load Identification and Collision Detection	80 kB	40 kB	

For RAPID memory consumption, see the RAPID Developer’s Manual. As an example, a MoveL or MoveJ instruction consumes 236 bytes when the robtarget is stored in the instruction (marked with ‘*’) and 168 bytes if a named robtarget is used. In the latter case, the CONST declaration of the named robtarget consumes an additional 280 bytes.

5.2 Teach Pendant Language

The robot is delivered with the selected language installed. The other languages are also delivered and can be installed.

5.3 Robot Documentation

A complete set of documentation consisting of:

- User’s Guide, with step by step instructions on how to operate and program the robot. This manual also includes a chapter called Basic Operation, which is an introduction to the basic operation and programming of the robot, and is suitable as a tutorial.
- RAPID Reference Manual, a description of the programming language.
- Product Manual, a description of the installation of the robot, maintenance procedures and troubleshooting. The Product Specification is included.

If the Danish language is chosen, the RAPID Reference Manual and parts of the Product Manual will be in English.

CONTENTS

Safety

1 General

This information on safety covers functions that have to do with the operation of the industrial robot.

The information does not cover how to design, install and operate a complete system, nor does it cover all peripheral equipment, which can influence the safety of the total system.

To protect personnel, the complete system has to be designed and installed in accordance with the safety requirements set forth in the standards and regulations of the country where the robot is installed.

The users of ABB industrial robots are responsible for ensuring that the applicable safety laws and regulations in the country concerned are observed and that the safety devices necessary to protect people working with the robot system have been designed and installed correctly.

People who work with robots must be familiar with the operation and handling of the industrial robot, described in applicable documents, e.g. Users's Guide and Product Manual.

The diskettes which contain the robot's control programs must not be changed in any way because this could lead to the deactivation of safety functions, such as reduced speed.

1.1 Introduction

Apart from the built-in safety functions, the robot is also supplied with an interface for the connection of external safety devices.

Via this interface, an external safety function can interact with other machines and peripheral equipment. This means that control signals can act on safety signals received from the peripheral equipment as well as from the robot.

In the Product Manual/*Installation,* instructions are provided for connecting safety devices between the robot and the peripheral equipment.

2 Applicable Safety Standards

The robot is designed in accordance with the requirements of ISO10218, Jan. 1992, Industrial Robot Safety. The robot also fulfils the ANSI/RIA 15.06-1992 stipulations.

3 Fire-Extinguishing

⚠ **Use a CARBON DIOXIDE extinguisher in the event of a fire in the robot (manipulator or controller).**

4 Definitions of Safety Functions

Emergency stop – IEC 204-1,10.7

A condition which overrides all other robot controls, removes drive power from robot axis actuators, stops all moving parts and removes power from other dangerous functions controlled by the robot.

Enabling device – ISO 11161, 3.4

A manually operated device which, when continuously activated in one position only, allows hazardous functions but does not initiate them. In any other position, hazardous functions can be stopped safely.

Safety stop – ISO 10218 (EN 775), 6.4.3

When a safety stop circuit is provided, each robot must be delivered with the necessary connections for the safeguards and interlocks associated with this circuit. It is necessary to reset the power to the machine actuators before any robot motion can be initiated. However, if only the power to the machine actuators is reset, this should not suffice to initiate any operation.

Reduced speed – ISO 10218 (EN 775), 3.2.17

A single, selectable velocity provided by the robot supplier which automatically restricts the robot velocity to that specified in order to allow sufficient time for people either to withdraw from the hazardous area or to stop the robot.

Interlock (for safeguarding) – ISO 10218 (EN 775), 3.2.8

A function that interconnects a guard(s) or a device(s) and the robot controller and/or power system of the robot and its associated equipment.

Hold-to-run control – ISO 10218 (EN 775), 3.2.7

A control which only allows movements during its manual actuation and which causes these movements to stop as soon as it is released.

5 Safe Working Procedures

Safe working procedures must be used to prevent injury. No safety device or circuit may be modified, bypassed or changed in any way, at any time.

5.1 Normal operations

All normal operations in automatic mode must be executed from outside the safeguarded space.

6 Programming, Testing and Servicing

The robot is extremely heavy and powerful, even at low speed. When entering into the robot’s safeguarded space, the applicable safety regulations of the country concerned must be observed.

Operators must be aware of the fact that the robot can make unexpected movements. A pause (stop) in a pattern of movements may be followed by a movement at high speed. Operators must also be aware of the fact that external signals can affect robot programs in such a way that a certain pattern of movement changes without warning.

If work must be carried out within the robot’s work envelope, the following points must be observed:

- The operating mode selector on the controller must be in the manual mode position to render the enabling device operative and to block operation from a computer link or remote control panel.
- The robot’s speed is limited to max. 250 mm/s (10 inches/s) when the operating mode selector is in position < 250 mm/s. This should be the normal position when entering the working space. The position 100% – full speed – may only be used by trained personnel who are aware of the risks that this entails.

Do not change “Transm gear ratio” or other kinematic parameters from the teach pendant or a PC. This will affect the safety function *Reduced speed 250 mm/s*.

- During programming and testing, the enabling device must be released as soon as there is no need for the robot to move.

The enabling device must never be rendered inoperative in any way.

- The programmer must always take the teach pendant with him/her when entering through the safety gate to the robot’s working space so that no-one else can take over control of the robot without his/her knowledge.

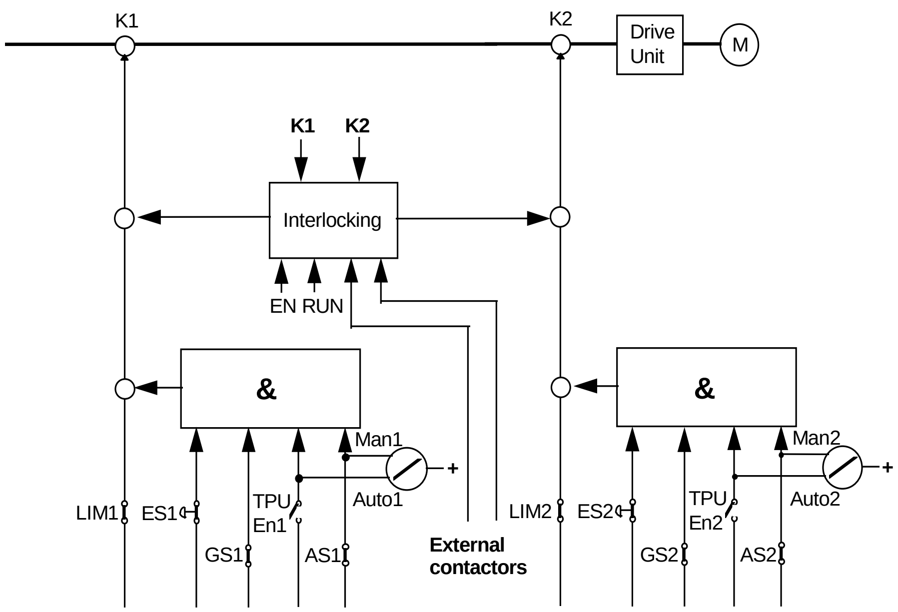
7 Safety Functions

7.1 The safety control chain of operation

The safety control chain of operation is based on dual electrical safety chains which interact with the robot computer and enable the MOTORS ON mode.

Each electrical safety chain consist of several switches connected in such a way that all of them must be closed before the robot can be set to MOTORS ON mode. MOTORS ON mode means that drive power is supplied to the motors.

If any contact in the safety chain of operation is open, the robot always reverts to MOTORS OFF mode. MOTORS OFF mode means that drive power is removed from the robot's motors and the brakes are applied.



The status of the switches is indicated by LEDs on top of the panel module in the control cabinet and is also displayed on the teach pendant (I/O window).

After a stop, the switch must be reset at the unit which caused the stop before the robot can be ordered to start again.

The time limits for the central two channel cyclic supervisions of the safety control chain is between 2 and 4 second.

The safety chains must never be bypassed, modified or changed in any other way.

7.2 Emergency stops

An emergency stop should be activated if there is a danger to people or equipment. Built-in emergency stop buttons are located on the operator's panel of the robot controller and on the teach pendant.

External emergency stop devices (buttons, etc.) can be connected to the safety chain by the user (see Product Manual/*Installation*). They must be connected in accordance with the applicable standards for emergency stop circuits.

Before commissioning the robot, all emergency stop buttons or other safety equipment must be checked by the user to ensure their proper operation.

Before switching to MOTORS ON mode again, establish the reason for the stop and rectify the fault.

7.3 Mode selection using the operating mode selector

The applicable safety requirements for using robots, laid down in accordance with ISO/DIS 10218, are characterised by different modes, selected by means of control devices and with clear-cut positions.

One automatic and two manual modes are available:

Manual mode:
< 250 mm/s - max. speed is 250mm/s
100% - full speed

Automatic mode: The robot can be operated via a remote control device

The manual mode, < 250 mm/s or 100%, must be selected whenever anyone enters the robot's safeguarded space. The robot must be operated using the teach pendant and, if 100% is selected, using Hold-to-run control.

In automatic mode, the operating mode selector is switched to , and all safety arrangements, such as doors, gates, light curtains, light beams and sensitive mats, etc., are active. No-one may enter the robot's safeguarded space. All controls, such as emergency stops, the control panel and control cabinet, must be easily accessible from outside the safeguarded space.

Programming and testing at reduced speed

Robot movements at reduced speed can be carried out as follows:

- Set the operating mode selector to <250 mm/s
- Programs can only be started using the teach pendant with the enabling device activated.

The automatic mode safeguarded space stop (AS) function is not active in this mode.

Testing at full speed

Robot movements at programmed speed can be carried out as follows:

- Set the operating mode selector to 100%
- Programs can only be started using the teach pendant with the enabling device activated.

For “Hold-to-run control”, the Hold-to-run button must be activated. Releasing the button stops program execution.

The 100% mode may only be used by trained personnel. The applicable laws and regulations of the countries where the robot is used must always be observed.

Automatic operation

Automatic operation may start when the following conditions are fulfilled:

- The operating mode selector is set to
- The MOTORS ON mode is selected

Either the teach pendant can be used to start the program or a connected remote control device. These functions should be wired and interlocked in accordance with the applicable safety instructions and the operator must always be outside the safeguarded space.

7.4 Enabling device

When the operating mode selector is in the MANUAL or MANUAL FULL SPEED position, the robot can be set to the MOTORS ON mode by depressing the enabling device on the teach pendant.

Should the robot revert to the MOTORS OFF mode for any reason while the enabling device is depressed, the latter must be released before the robot can be returned to the MOTORS ON mode again. This is a safety function designed to prevent the enabling device from being rendered inactive.

When the enabling device is released, the drive power to the motors is switched off, the brakes are applied and the robot reverts to the MOTORS OFF mode.

If the enabling device is reactivated, the robot changes to the MOTORS ON mode.

7.5 Hold-to-run control

This function is always active when the operating mode selector is in the MANUAL FULL SPEED position. It is possible to set a parameter to make this function active also when the operating mode selector is in the MANUAL position.

When the Hold-to-run control is active, the enabling device and the Hold-to-run button on the teach pendant must be depressed in order to execute a program. When the button is released, the axis (axes) movements stop and the robot remains in the MOTORS ON mode.

Here is a detailed description of how to execute a program in Hold-to-run control:

• Activate the enabling device on the teach pendant.

• Choose execution mode using the function keys on the teach pendant:

- **Start** (continuous running of the program)
- **FWD** (one instruction forwards)
- **BWD** (one instruction backwards)

• Wait for the Hold-to-run alert box.

• Activate the Hold-to-run button on the teach pendant.

Now the program will run (with the chosen execution mode) as long as the Hold-to-run button is pressed. Releasing the button stops program execution and activating the button will start program execution again.

For FWD and BWD execution modes, the next instruction is run by releasing and activating the Hold-to-run button.

It is possible to change execution mode when the Hold-to-run button is released and then continue the program execution with the new execution mode, by just activating the Hold-to-run button again, i.e. no alert box is shown.

If the program execution was stopped with the Stop button on the teach pendant, the program execution will be continued by releasing and activating the Hold-to-run button.

When the enabling device on the teach pendant is released, the sequence described above must be repeated from the beginning.

7.6 General Mode Safeguarded Stop (GS) connection

The GS connection is provided for interlocking external safety devices, such as light curtains, light beams or sensitive mats. The GS is active regardless of the position of the operating mode selector.

When this connection is open the robot changes to the MOTORS OFF mode. To reset to MOTORS ON mode, the device that initiated the safety stop must be interlocked in accordance with applicable safety regulations. This is not normally done by resetting the device itself.

7.7 Automatic Mode Safeguarded Stop (AS) connection

The AS connection is provided for interlocking external safety devices, such as light curtains, light beams or sensitive mats used externally by the system builder. The AS is especially intended for use in automatic mode, during normal program execution.

The AS is by-passed when the operating mode selector is in the MANUAL or MANUAL FULL SPEED position.

7.8 Limiting the working space

NOTE! Not valid for IRB 340(r)

For certain applications, movement about the robot's main axes must be limited in order to create a sufficiently large safety zone. This will reduce the risk of damage to the robot if it collides with external safety arrangements, such as barriers, etc.

Movement about axes 1, 2 and 3 can be limited with adjustable mechanical stops or by means of electrical limit switches. If the working space is limited by means of stops or switches, the corresponding software limitation parameters must also be changed. If necessary, movement of the three wrist axes can also be limited by the computer software. Limitation of movement of the axes must be carried out by the user.

7.9 Supplementary functions

Functions via specific digital inputs:

- A stop can be activated via a connection with a digital input. Digital inputs can be used to stop programs if, for example, a fault occurs in the peripheral equipment.

Functions via specific digital outputs:

- Error – indicates a fault in the robot system.
- Cycle_on – indicates that the robot is executing a program.
- MotOnState/MotOffState – indicates that the robot is in MOTORS ON / MOTORS OFF mode.
- EmStop - indicates that the robot is in emergency stop state.
- AutoOn - indicates that the robot is in automatic mode.

8 Safety Risks Related to End Effectors

8.1 Gripper

If a gripper is used to hold a workpiece, inadvertent loosening of the workpiece must be prevented.

8.2 Tools/workpieces

It must be possible to turn off tools, such as milling cutters, etc., safely. Make sure that guards remain closed until the cutters stop rotating.

Grippers must be designed so that they retain workpieces in the event of a power failure or a disturbance of the controller. It should be possible to release parts by manual operation (valves).

8.3 Pneumatic/hydraulic systems

Special safety regulations apply to pneumatic and hydraulic systems.

Residual energy may be present in these systems so, after shutdown, particular care must be taken.

The pressure in pneumatic and hydraulic systems must be released before starting to repair them. Gravity may cause any parts or objects held by these systems to drop. Dump valves should be used in case of emergency. Shot bolts should be used to prevent tools, etc., from falling due to gravity.

9 Risks during Operation Disturbances

If the working process is interrupted, extra care must be taken due to risks other than those associated with regular operation. Such an interruption may have to be rectified manually.

Remedial action must only ever be carried out by trained personnel who are familiar with the entire installation as well as the special risks associated with its different parts.

The industrial robot is a flexible tool which can be used in many different industrial applications. All work must be carried out professionally and in accordance with applicable safety regulations. Care must be taken at all times.

10 Risks during Installation and Service

Never use the robot as a ladder, i.e. do not climb on the robot motors or other parts during service work. There is a serious risk of slipping because of the high temperature of the motors or oil spills that can occur on the robot.

To prevent injuries and damage during the installation of the robot system, the regulations applicable in the country concerned and the instructions of ABB Robotics must be complied with. Special attention must be paid to the following points:

• The supplier of the complete system must ensure that all circuits used in the safety

function are interlocked in accordance with the applicable standards for that function.

- The instructions in the Product Manual/*Installation* must always be followed.
- The mains supply to the robot must be connected in such a way that it can be turned off outside the robot's working space.
- The supplier of the complete system must ensure that all circuits used in the emergency stop function are interlocked in a safe manner, in accordance with the applicable standards for the emergency stop function.
- Emergency stop buttons must be positioned in easily accessible places so that the robot can be stopped quickly.
- Safety zones, which have to be crossed before admittance, must be set up in front of the robot's working space. Light beams or sensitive mats are suitable devices.
- Turntables or the like should be used to keep the operator away from the robot's working space.
- Those in charge of operations must make sure that safety instructions are available for the installation in question.
- Those who install the robot must have the appropriate training for the robot system in question and in any safety matters associated with it.

Although troubleshooting may, on occasion, have to be carried out while the power supply is turned on, the robot must be turned off (by setting the mains switch to OFF) when repairing faults, disconnecting electric leads and disconnecting or connecting units.

Even if the power supply for the robot is turned off, you can still injure yourself.

- The axes are affected by the force of gravity when the brakes are released. In addition to the risk of being hit by moving robot parts, you run the risk of being crushed by the tie rod.
- Energy, stored in the robot for the purpose of counterbalancing certain axes, may be released if the robot, or parts thereof, is dismantled.
- When dismantling/assembling mechanical units, watch out for falling objects.
- Be aware of stored energy (DC link) and hot parts in the controller.
- Units inside the controller, e.g. I/O modules, can be supplied with external power.

11 The following standards are of interest when the robot is parts of a cell

EN 294	Safety of machinery - Safety distance to prevent danger zones being reached by the upper limbs.
EN 349	Safety of machinery - Minimum gaps to avoid crushing of parts of the human body.
EN 811	Safety of machinery - Safety distance to prevent danger zones being reached by the lower limbs.
Pr EN 999	Safety of machinery - The positioning of protective equipment in respect of approach speeds of the human body.
EN 1088	Safety of machinery - Inter locking device associated with guards principles for design and selection.

12 Risks Associated with Live Electric Parts

Controller

A danger of high voltage is associated with the following parts:

- The mains supply/mains switch
- The power unit
- The power supply unit for the computer system (55 V AC)
- The rectifier unit (260 V AC and 370 V DC. NB: Capacitors!)
- The drive unit (370 V DC)
- The service outlets (115/230 VAC)
- The power supply unit for tools, or special power supply units for the machining process
- The external voltage connected to the control cabinet remains live even when the robot is disconnected from the mains.
- Additional connections

Manipulator

A danger of high voltage is associated with the manipulator in:

- The power supply for the motors (up to 370 V DC)
- The user connections for tools or other parts of the installation (see *Installation*, max. 230 V AC)

Tools, material handling devices, etc.

Tools, material handling devices, etc., may be live even if the robot system is in the OFF position. Power supply cables which are in motion during the working process may be damaged.

13 Emergency Release of Mechanical Arm

If an emergency situation occur where a person is trapped by the mechanical robot arm, the brake release buttons should be pressed whereby the arms can be moved to release the person. To move the arms by manpower is normally possible on the smaller robots (1400 and 2400), but for the bigger ones it might not be possible without a mechanical lifting device, like an overhead crane.

If power is not available the brakes are applied, and therefore manpower might not be sufficient for any robot.

Before releasing the brakes, be sure that the weight of the arms does not enhance the pressure on the trapped person.

14 Limitation of Liability

The above information regarding safety must not be construed as a warranty by ABB Robotics that the industrial robot will not cause injury or damage even if all safety instructions have been complied with.

15 Related Information

	Described in:
Installation of safety devices	Product Manual - *Installation and Commissioning*
Changing robot modes	User's Guide - *Starting up*
Limiting the working space	Product Manual - *Installation and Commissioning*

To the User

"Declaration by the manufacturer".
This is only a translation of the customs declaration. The original document (in English) with the serial number on it is supplied together with the robot

Declaration by the manufacturer
as defined by machinery directive 89/392/EEC Annex II B

Herewith we declare that the industrial robot

☐ IRB 1400	☐ IRB 2000	☐ IRB 2400	☐ IRB 3000	☐ IRB 3400
☐ IRB 4400	☐ IRB 6000	☐ IRB 6400	☐ IRB 6400C	☐ IRB 640

manufactured by ABB Robotics Products AB 721 68 Västerås, Sweden
with serial No.

Label with
serial number

is intended to be incorporated into machinery or assembled with other machinery to constitute machinery covered by this directive and must not be put into service until the machinery into which it is to be incorporated has been declared in conformity with the provisions of the directive, 91/368 EEC.

Applied harmonised standards in particular:

EN 292-1	Safety of machinery, basic terminology
EN 292-2	Safety of machinery, technical principles/specifications, emergency stop
EN 418	Safety of machinery, emergency stop equipment
EN 563	Safety of machinery, temperatures of surfaces
EN 614-1	Safety of machiney, ergonomic design principles
EN 775	Robot safety
EN 60204	Electrical equipment for industrial machines
prEN 574	Safety of machinery, two-hand control device
prEN 953	Safety of machinery, fixed / moveable guards
prEN 954-1	Safety of machinery, safety related parts of the control system
EN 50081-2	EMC, Generic emission standard. Part 2: Industrial environment
EN 55011 Class A	Radiated emission enclosure
EN 55011 Class A	Conducted emission AC Mains
EN 50082-2	EMC, Generic immunity standard. Part 2: Industrial environment
EN 61000-4-2	Electrostatic discharge immunity test
EN 61000-4-3	Radiated, radio-frequency, electromagnetic field immunity yest
ENV 50204	Radeated electromagnetic field from digital radio telephones, immunity test
EN 61000-4-4	Electrical fast transient/burst immunity test
ENV 50141	Conducted disturbences induced by radio-frequency fields, immunity test

Prepared M Jonsson, 970904	Responsible department SEROP/K	Title Technical Provisions	
Approved by,date K-G Ramström, 970905 Product Design Responsible	Take over department	Declaration by the manuf.	Page 1
Status **APPROVED**		Tillverkardeklaration	No.of pages 1
ABB	**ABB Robotics Products**	Document No 3HAB 3585-1	Rev. ind. 08

ABB ROBOTICS PRODUCTS AB **CONFIGURATION LIST**

Robot type: Revision: Manufact order no: Serial no:

For RAC: RAC Ref no: Sales order no:

Tested and approved: Date Name

MANIPULATOR:

CONTROL

ROBOT SY

Delivery fro

Delivery to

> **To the User**
>
> The Configuration List is an individual specification of the robot system delivered regarding configuration and extent.
>
> On delivery, the complete document is placed in the robot controller.

Acceptance by customer: ______________________________________

Customer information: ______________________________________

Customer:

Address:

OPTIONS/DOCUMENTATION

QTY	OPTION/PARTNO	REVISION	DESCRIPTION

CONTENTS

CONTENTS

Page

1 Structure

The robot is made up of two main parts, manipulator and controller, described in sections 1.1 and 1.2.

1.1 Manipulator

It is equipped with maintenance-free, AC motors which have electromechanical brakes. The brakes lock the motors when the robot is inoperative for more than 1000 hours. The time is configurabble for the user.

The following figures shows the various ways in which the different manipulators moves and its component parts.

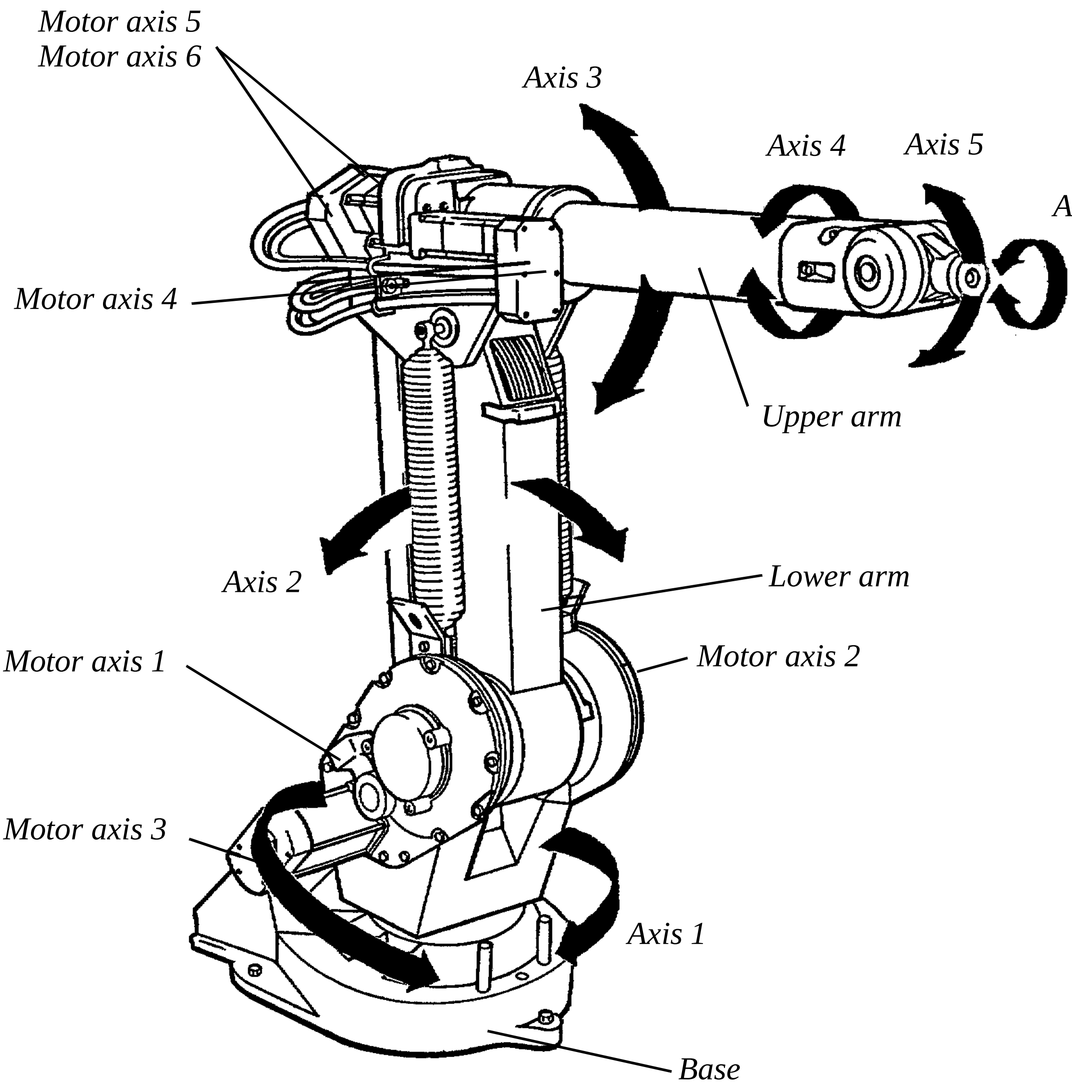


Figure 1 The motion patterns of the IRB 1400 and IRB 140.

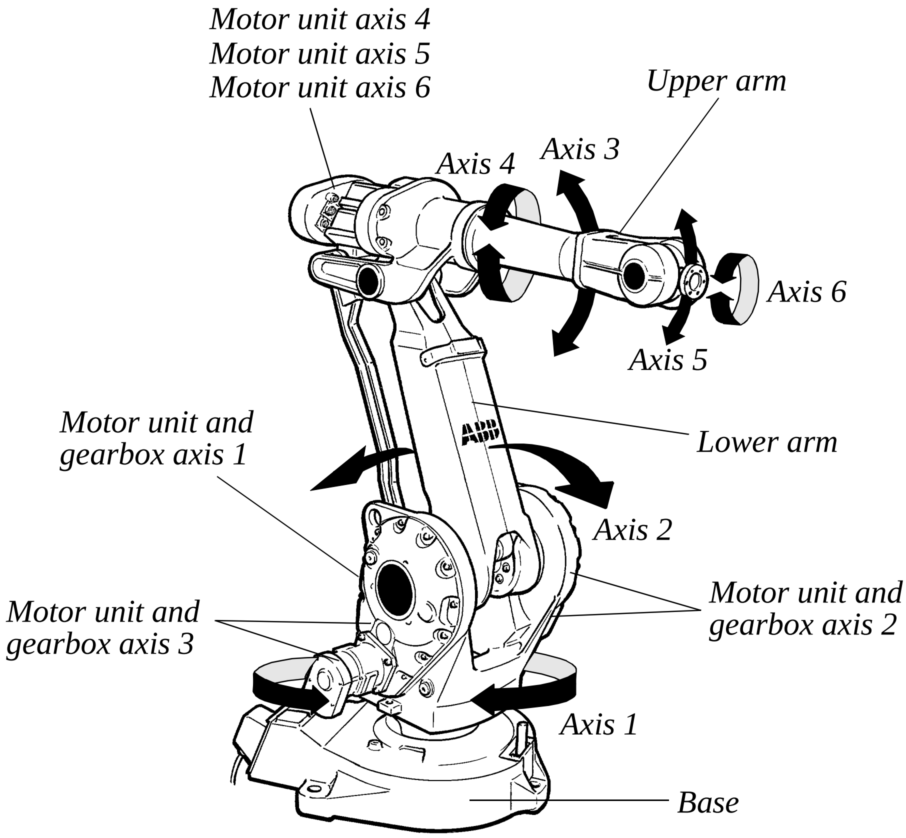


Figure 2 The motion patterns of the IRB 2400.

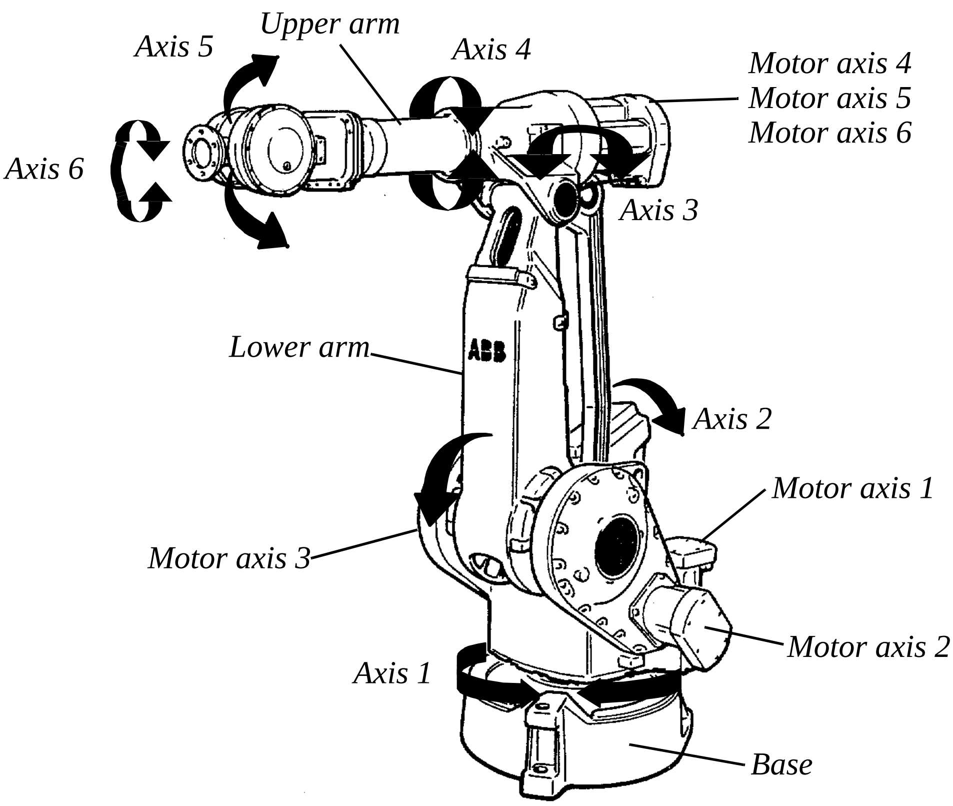


Figure 3 The motion patterns of the IRB 4400.

Figure 4 The motion patterns of the IRB 6400.

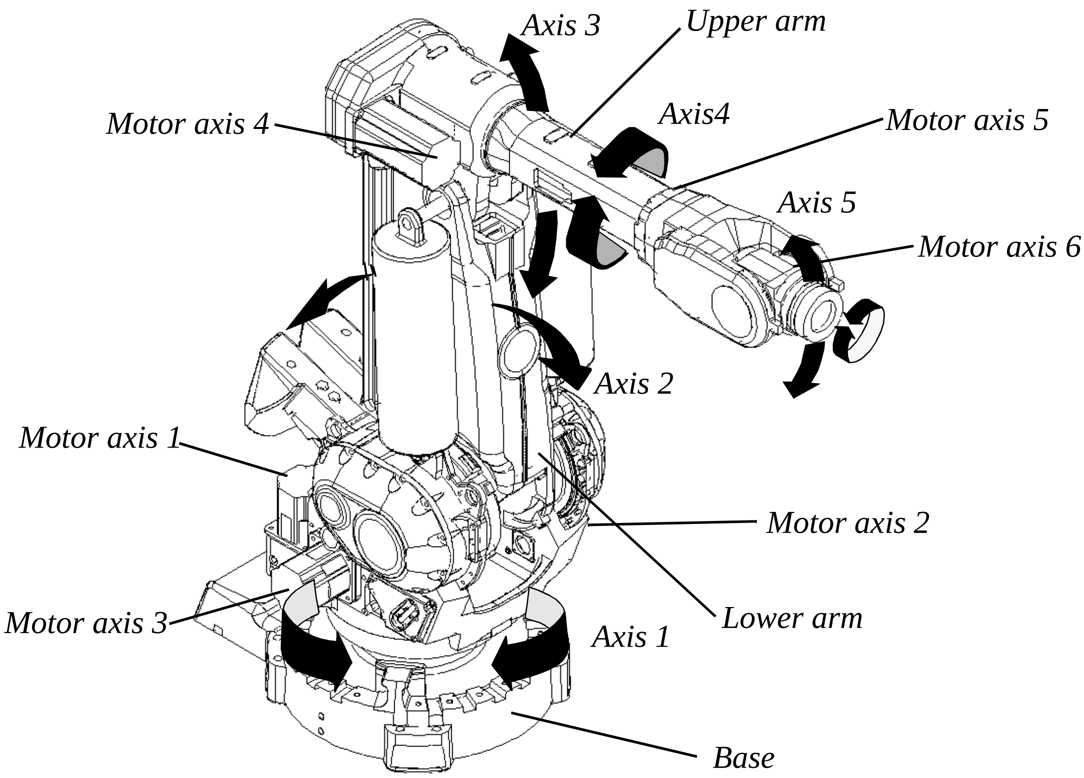


Figure 5 The motion patterns of the IRB 6400R M99.

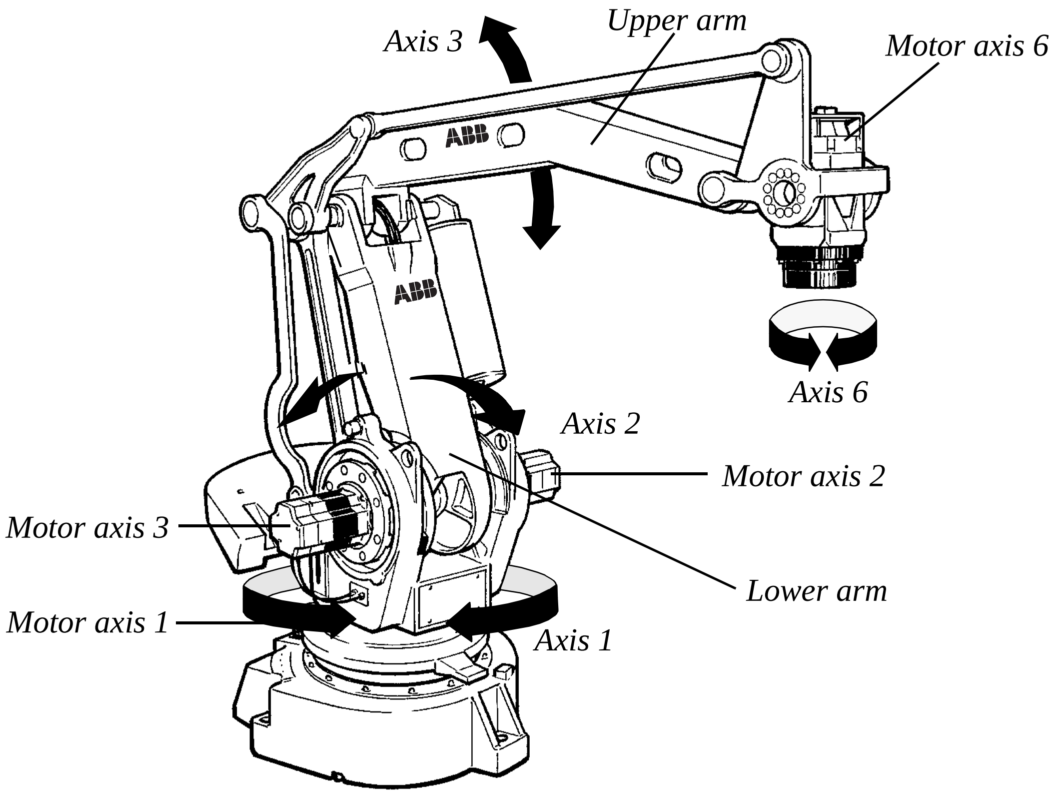


Figure 6 The motion patterns of the IRB 640.

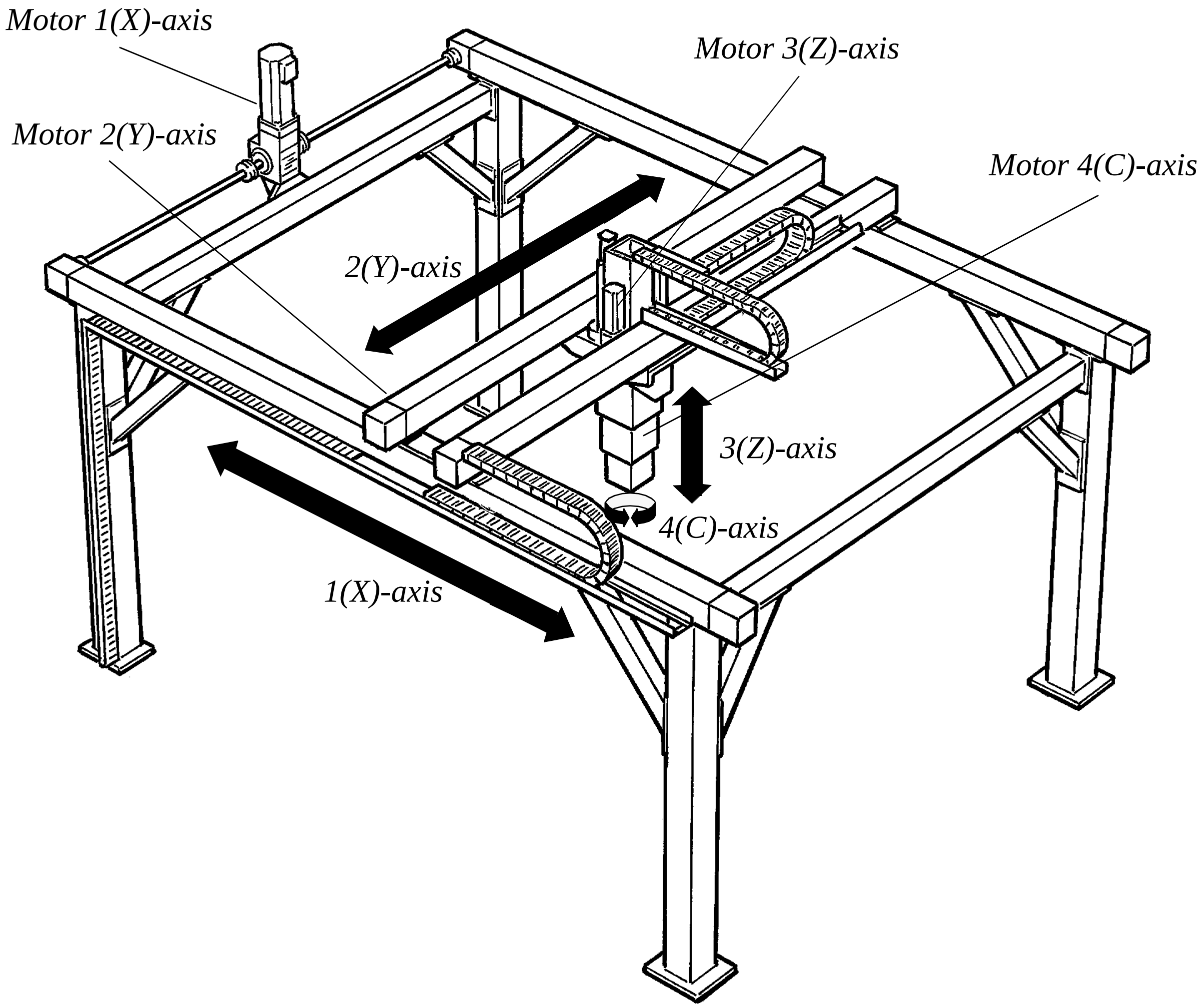


Figure 7 The motion patterns of the IRB 840/A

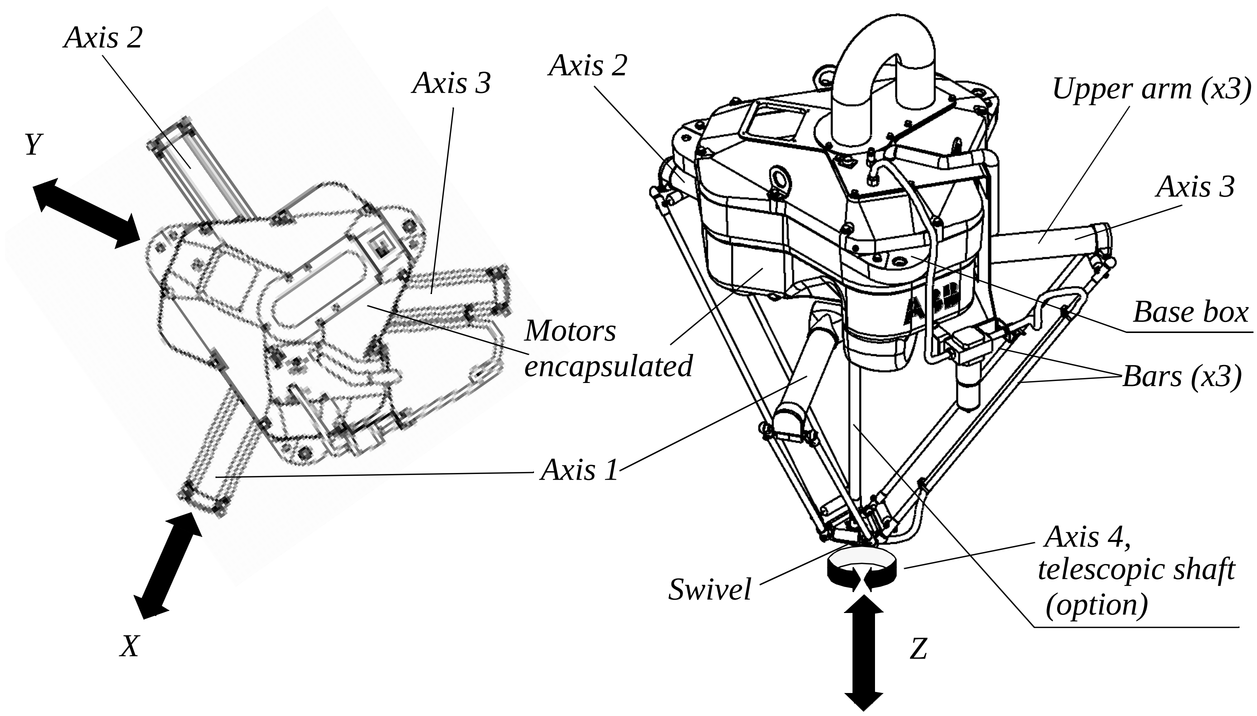


Figure 8 The motion patterns of the IRB 340.

1.2 Controller

The controller, which contains the electronics used to control the manipulator and peripheral equipment, is specifically designed for robot control, and consequently provides optimal performance and functionality.

Figure 9 shows the location of the various components on the cabinet.

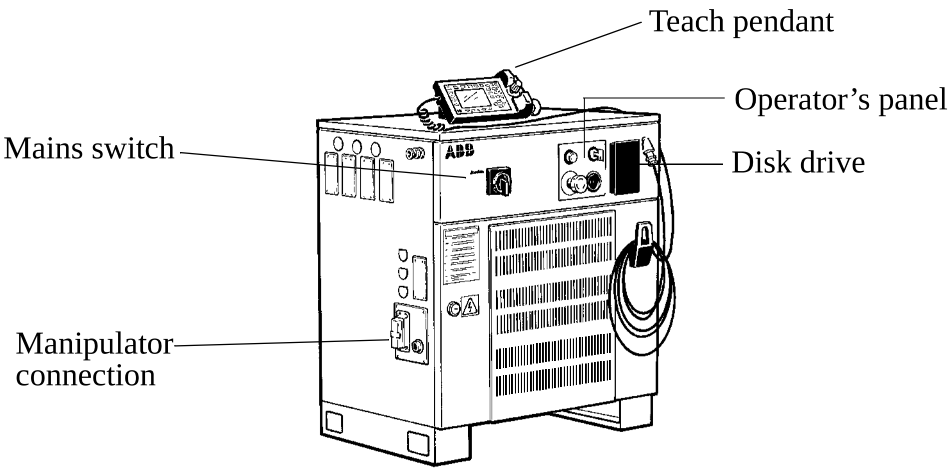


Figure 9 The exterior of the cabinet showing the location of the various units.

1.3 Electronics unit

All control and supervisory electronics, apart from the serial measurement board, which is located inside the manipulator, are gathered together inside the controller.

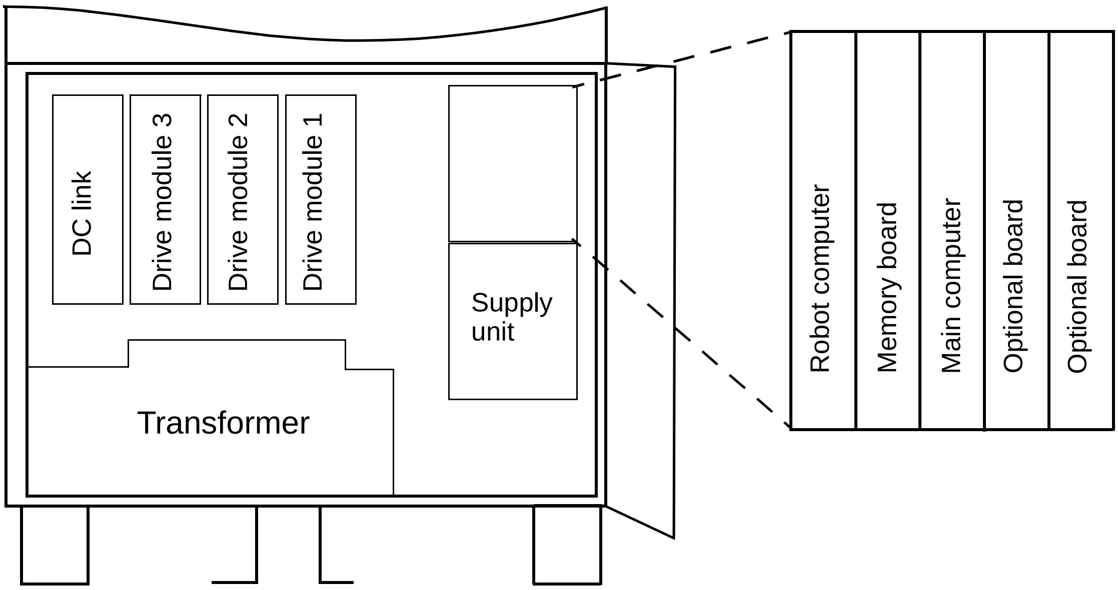


Figure 10 The location of the electronics boards and units behind the front door.

The computer unit (supply unit + board backplane) comprises the following parts:

- Robot computer board –
  contains computers used to control the manipulator motion and I/O communication.
- Memory board –
  contains extra RAM memory, there are three sizes, 8 and 16 MB.
- Main computer board –
  contains 8 MB RAM memory and the main computer, which controls the entire robot system.
- Optional boards-
  Communication boards, containing circuits for network and field bus communication.
- Supply unit–
  4 regulated and short-circuit-protected output voltages.

Drive system:

- DC link–
  converts a three-phase AC voltage to a DC voltage.
- Drive module –
  controls the torque of 2-3 motors.

When the maximum capacity for external axes is utilized, a second control cabinet is used. The external axes cabinet comprises AC connection, main switch, contactors,

transformer, DC-link, drive module(s), and supply unit, but no computer unit.

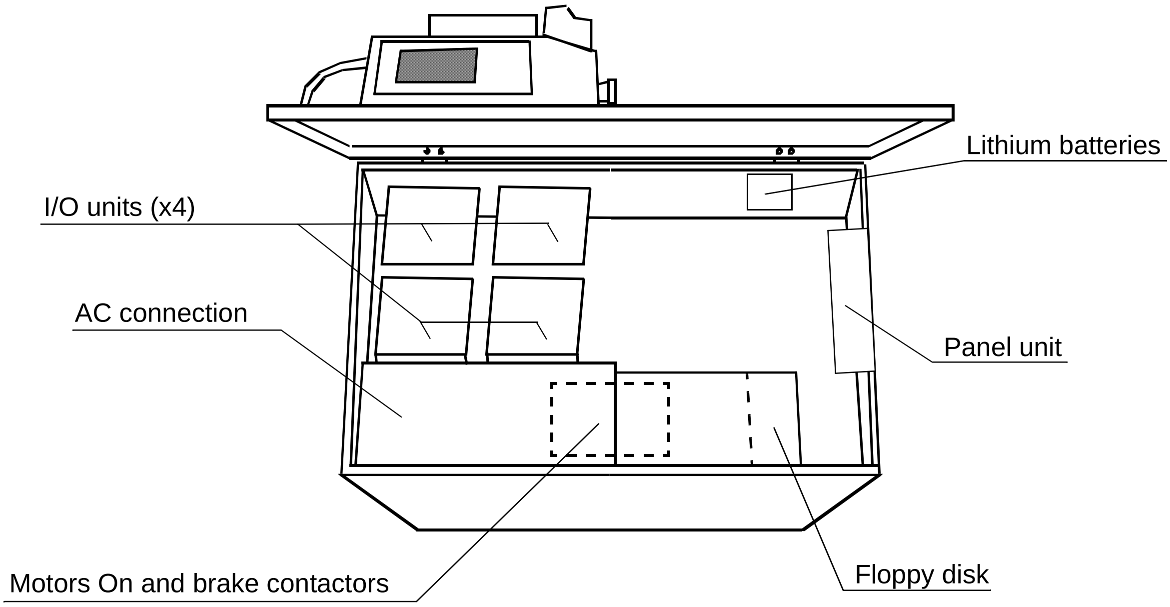


Figure 11 The location of units under the top cover.

- Lithium batteries for memory back-up.
- Panel unit –
  gathers and coordinates all signals that affect operational and personal safety.
- I/O units –
  enables communication with external equipment by means of digital inputs and outputs, analog signals or field buses.

  I/O units can alternatively be located outside the cabinet. Communication with robot data is implemented via a stranded wire CAN bus, which allows the units to be positioned close to the process.
- Serial measurement board (in the manipulator) –
  gathers resolver data and transfers it serially to the robot computer board. The serial measurement board is battery-backed so that the revolution information cannot be lost during a power failure.

2 Computer System

The computer system is made up of three computers on two circuit boards. The computers comprise:

- Main computer board –
  contains the *main computer* of the robot and controls the entire robot.
- Robot computer board –
  contains the *I/O computer* which acts as a link between the main computer, the world around and the *axis computer* that regulates the velocity of the robot axes.

To find out where the various boards are located, see Electronics unit on page 10.

The computers are the data processing centre of the robot. They possess all the functions required to create, execute and store a robot program. They also contain functions for coordinating and regulating the axis movements. Figure 12 shows how the computer system communicates with the other units.

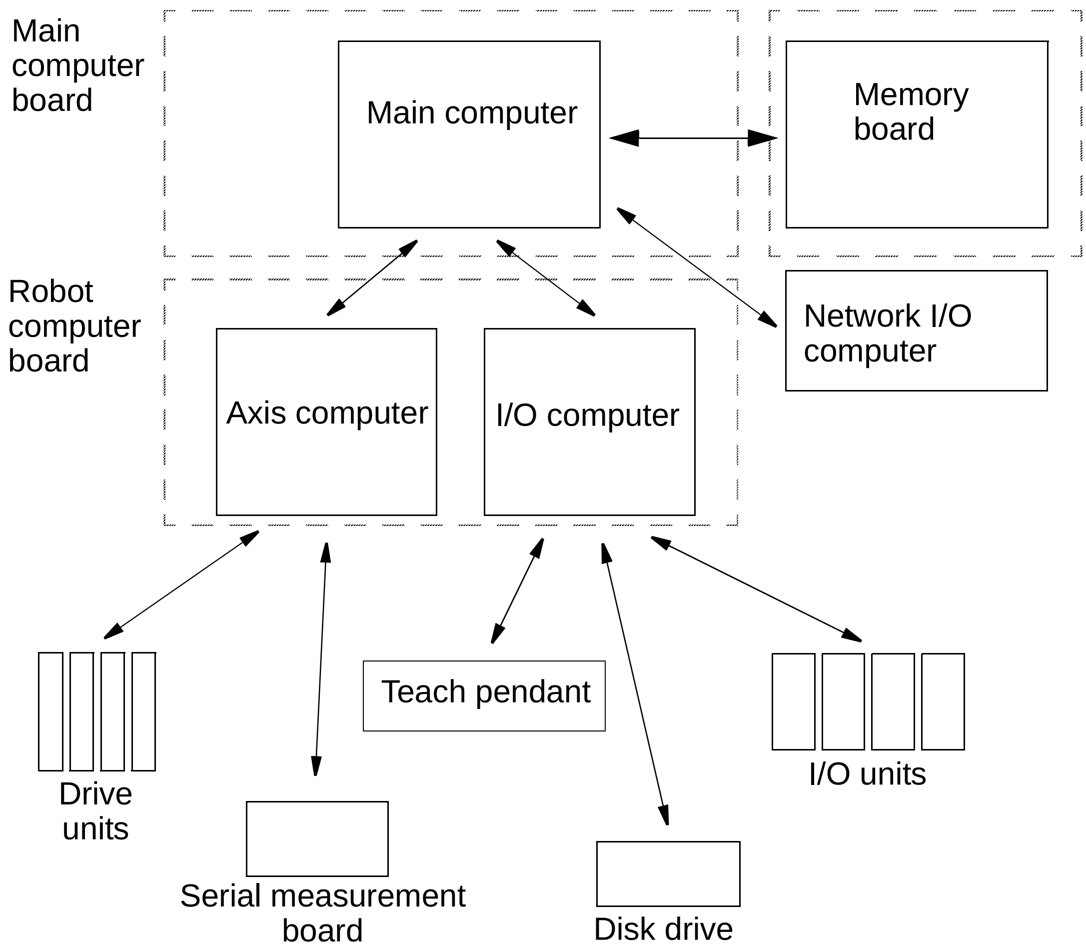


Figure 12 The interfaces of the computer system.

3 Servo System

3.1 Principle function

The servo system is a complex system comprising several different interacting units and system parts – both hardware and software. The servo function comprises:

- Digital regulation of the poses, velocity and motor current of the robot axes.
- Synchronous AC operation of the robot motors.

3.2 Regulation

During execution, new data on the poses of the robot axes is continuously received from the serial measurement board. This data is input into the position regulator and then compared with previous position data. After it has been compared and amplified, new references are given for the pose and velocity of the robot.

The system also contains a model of the robot which continuously calculates the optimal regulator parameters for the gravitation, the moment of inertia and the interaction between axes. See Figure 13.

3.3 Controlling the robot

An digital current reference for two phases is calculated on the basis of the resolver signal and a known relationship between the resolver angle and rotor angle. The third phase is created from the other two.

The current of the phases is regulated in the drive unit in separate current regulators. In this way, three voltage references are returned which, by pulse-modulating the rectifier voltage, are amplified to the working voltage of the motors.

The serial measurement board receives resolver data from a maximum of six resolvers and generates information on the position of the resolvers.

The following diagrams outline the system structure for AC operation as well as the fundamental structure of the drive unit.

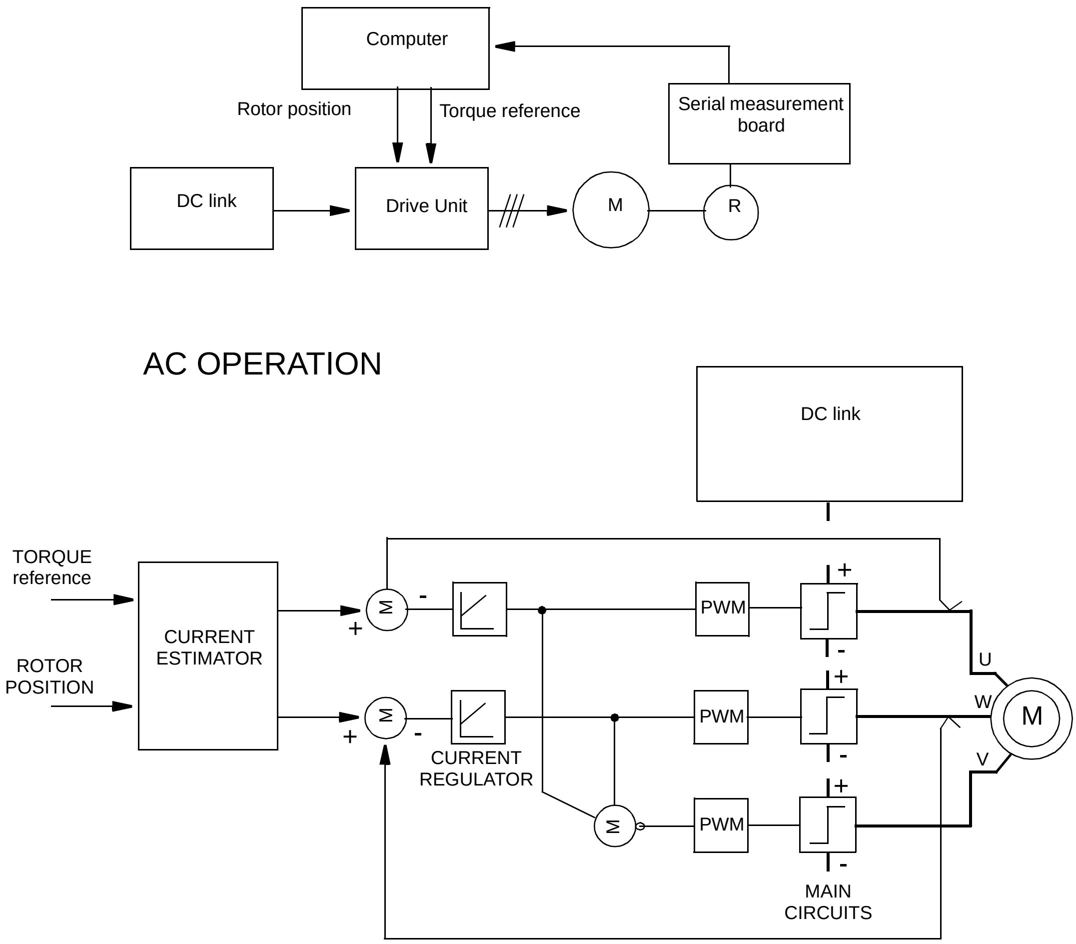


Figure 13 System structure for AC operation.

3.4 Overload protection

PTC resistance is built into the robot motors to provide thermal protection against overloads. The PTC sensors are connected to an input on the panel unit which is sensitive to resistance level and which check that low resistance is maintained.

The robot computer checks the motors for overloading at regular intervals by reading the panel unit register. In the event of an overload, all motors are switched off.

4 I/O System

Communicates with other equipment using digital and analog input and output signals.

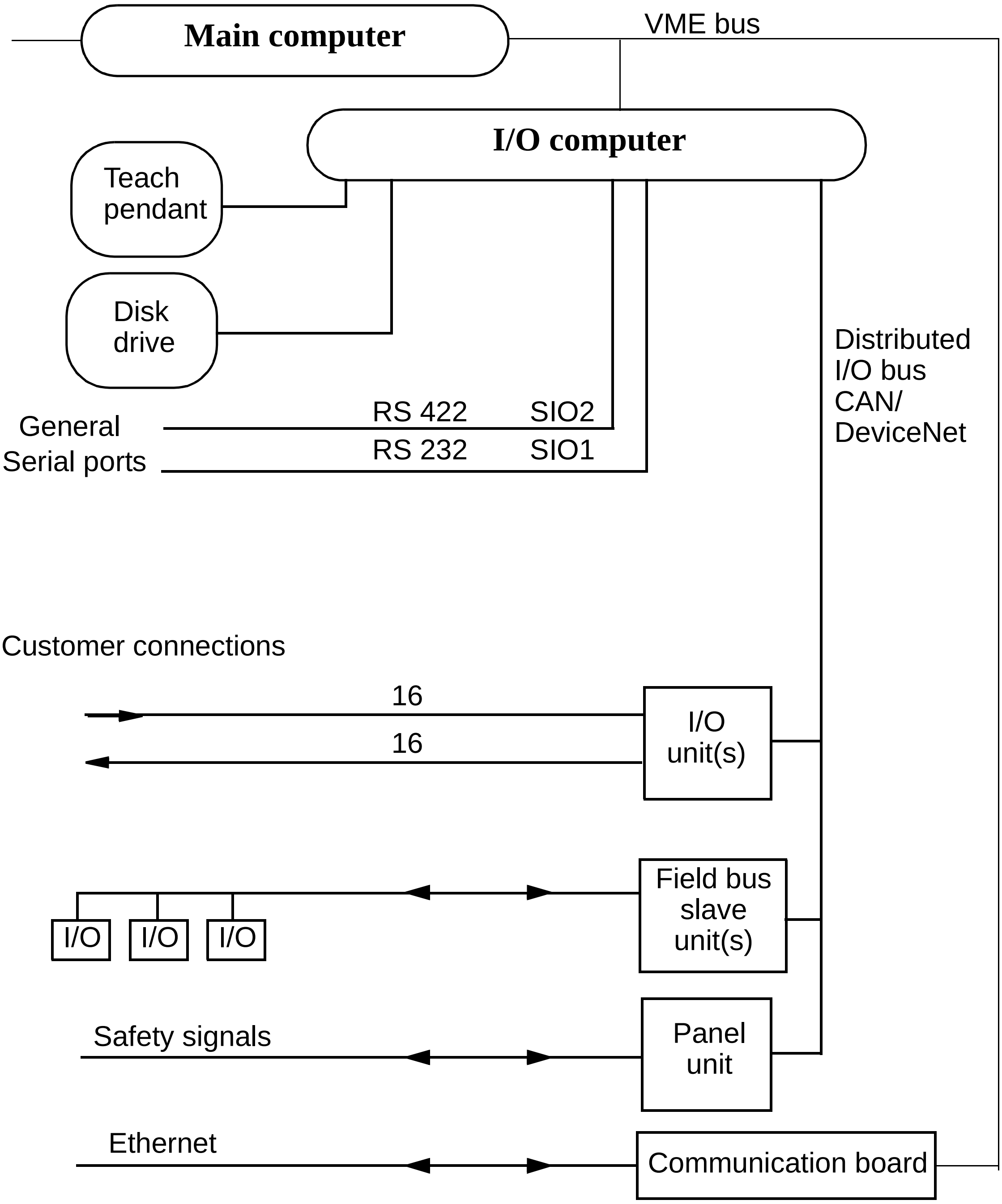


Figure 14 Overview of the I/O system.

5 Safety System

The robot’s safety system is based on a two-channel safety circuit that is continuously monitored. If an error is detected, the power supply to the motors is switched off and the brakes engage. To return the robot to MOTORS ON mode, the two identical chains of switches must be closed. As long as these two chains differ, the robot will remain in the MOTORS OFF mode.

Figure 15 below illustrates an outline principal circuit with available customer contacts.

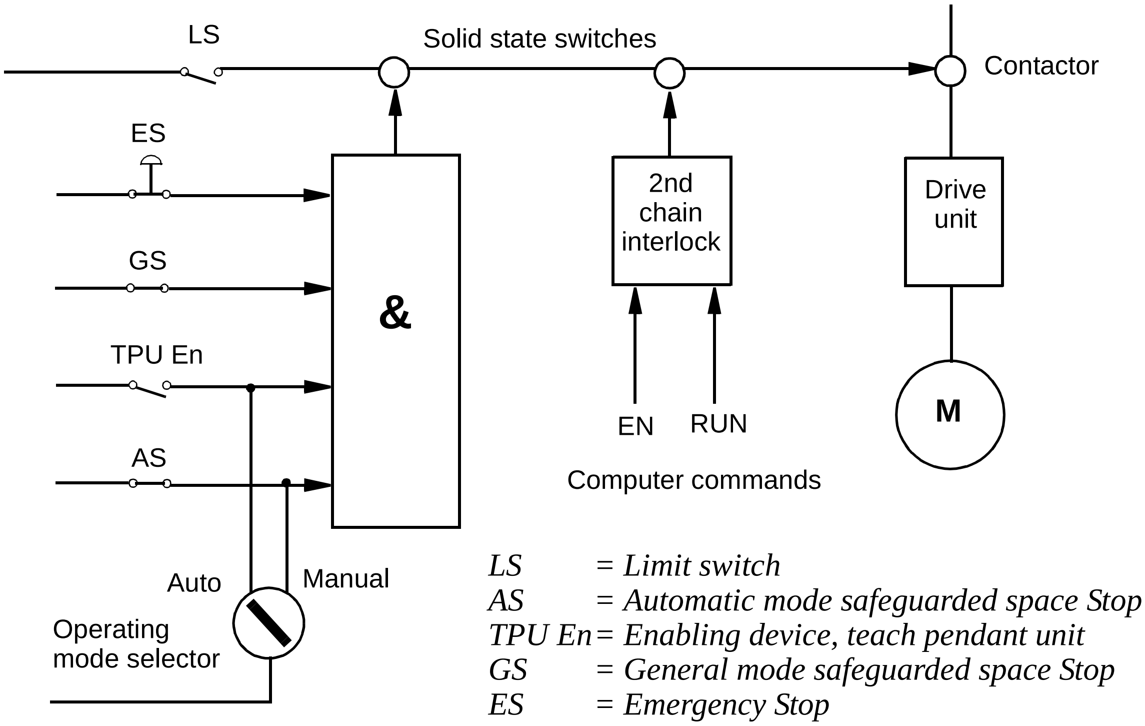


Figure 15 Outline diagram of one of the safety circuits.

5.1 The chain of operation

The emergency stop buttons on the operator’s panel and on the teach pendant and external emergency stop buttons are included in the two-channel chain of operation.

A safeguarded stop, AUTO STOP, which is active in the AUTO operating mode, can be connected by the user. In any of the MANUAL modes, the enabling device on the teach pendant overrides the AUTO STOP.

The safeguarded stop GENERAL STOP is active in all operating modes and is connected by the user.

The aim of these safeguarded stop functions is to make the area around the manipulator safe while still being able to access it for maintenance and programming.

If any of the dual switches in the safety circuit are opened, the circuit breaks, the motor contactors drop out, and the robot is stopped by the brakes. If the safety circuit breaks, an interrupt call is sent directly from the panel unit to the robot computer to ensure that the cause of the interrupt is indicated.

When the robot is stopped by a limit switch, it can be moved from this position by jogging it with the joystick while pressing the MOTORS ON button. The MOTORS ON button is monitored and may be depressed for a maximum of 30 seconds.

LEDs for ES, AS and GS are connected to the two safety circuits to enable quick location of the position where the safety chain is broken. The LEDs are located on the upper part of the panel unit. Status indication is also available on the teach pendant display.

5.2 MOTORS ON and MOTORS OFF modes

The principle task of the safety circuit is to ensure that the robot goes into MOTORS OFF mode as soon as any part of the chain is broken. The robot computer itself controls the last switches (ENABLE and MOTORS ON).

In AUTO mode, you can switch the robot back on by pressing the MOTORS ON button on the operator’s panel. If the circuit is OK, the robot computer then closes the MOTORS ON relay to complete the circuit. When switching to MANUAL, the mode changes to MOTORS OFF, at which stage the robot computer also opens the MOTORS ON relay. If the robot mode does not change to MOTORS OFF, the ENABLE chain will break and the ENABLE relay is opened. The safety circuit can thus be broken in two places by the robot computer.

In any of the MANUAL modes, you can start operating again by pressing the enabling device on the teach pendant. If the circuit is OK, the robot computer then closes the MOTORS ON relay to complete the circuit. The function of the safety circuit can be described as a combination of mechanical switches and robot computer controlled relays which are all continuously monitored by the robot computer.

5.3 Safety stop signals

According to the safety standard ISO/DIS 11161 “Industrial automation systems - safety of integrated manufacturing systems - Basic requirements”, there are two categories of safety stops, category 0 and category 1, see below:

The category 0 stop is to be used for safety analysis purposes, when the power supply to the motors must be switched off immediately, such as when a light curtain, used to protect against entry into the work cell, is passed. This uncontrolled motion stop may require special restart routines if the programmed path changes as a result of the stop.

Category 1 is preferred for safety analysis purposes, if it is acceptable, such as when gates are used to protect against entry into the work cell. This controlled motion stop takes place within the programmed path, which makes restarting easier.

All the robot’s safety stops are category 0 stops as default.
Safety stops of category 1 can be obtained by activating the soft stop (delayed stop) together with AS or GS. Activation is made by setting a parameter, see User’s Guide, section System Parameters, Topic: Controller.

5.4 Limitation of velocity

To program the robot, the operating mode switch must be turned to MANUAL REDUCED SPEED position. Then the robot's maximum velocity is limited to 250 mm/s.

5.5 ENABLE

ENABLE is a 24 V signal, generated in the supply unit. The signal is sent through the robot computer, to the panel unit.

The errors that affect the Enable signal are:

- In the supply unit; errors in the input voltage.
- In the robot computer; errors in the diagnostics or servo control program.
- In the drive unit; regulating errors and overcurrent.

5.6 24 V supervision

If the 24 V supply to the safety circuits drops out, the MOTORS ON contactors will drop out, causing the motors to switch off.

5.7 Monitoring

Monitoring is carried out using both hardware and software, and comprises the external part of the safety circuits, including switches and operating contacts. The hardware and software parts operate independently of each other.

The following errors may be detected:

All inputs from the safety circuits are linked to registers, which allows the robot computer to monitor the status. If an interrupt occurs in the circuit, the status can be read.

If any of the switch functions are incorrectly adjusted, causing only one of the chains of operation to be interrupted, the robot computer will detect this. By means of hardware interlocking it is not possible to enter MOTORS ON without correcting the cause.

6 External Axes

Not valid for IRB 340(r)!

External axes are controlled by drive units, mounted either inside the controller or outside in a separate enclosure, see Figure 16.

The maximum of drive units mounted inside the controller is one or two, depending on robot type.

In addition to drive units from ABB, it is also possible to communicate with external drive units from other vendors. See Product Specification RobotWare for BaseWare OS 3.1.

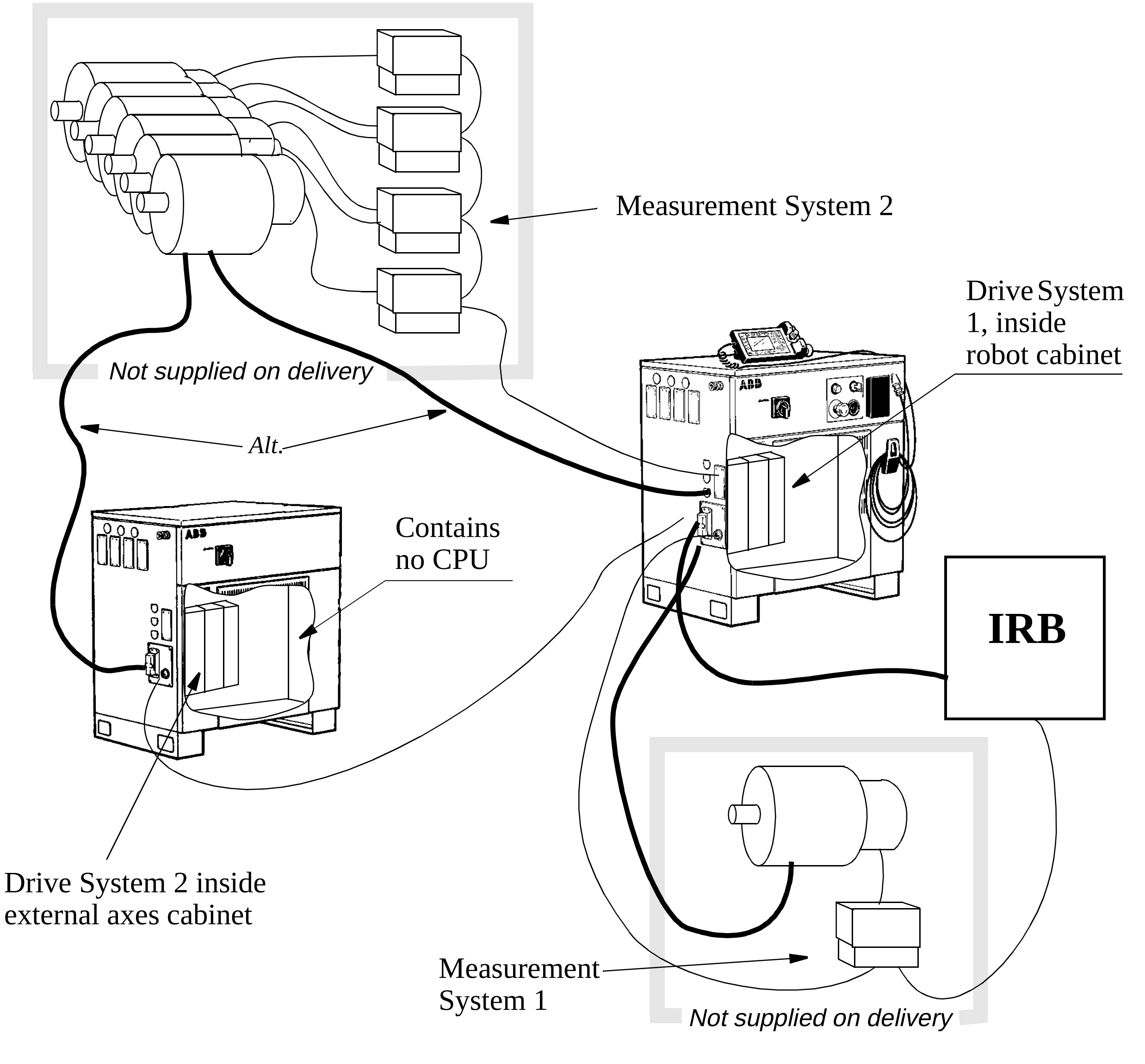


Figure 16 Outline diagram, external axes.

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1 Transporting and Unpacking

NB:
Before starting to unpack and install the robot, read the safety regulations and other instructions very carefully. These are found in separate sections in the User's Guide and Product manual.

The installation shall be made by qualified installation personnel and should conform to all national and local codes.

When you have unpacked the robot, check that it has not been damaged during transport or while unpacking.

If the Signal Lamp option is selected, the signal lamp is fitted under the protective cover on axis four housing to protect it during transport.

Operating conditions:

Ambient temperature	+5 ° to + 45°C (manipulator) + 5° to + 52°C (controller)
Relative humidity	Max. 95% at constant temperature

Storage conditions:

If the equipment is not going to be installed straight away, it must be stored in a dry area at an ambient temperature between -25°C and +55°C.

When air transport is used, the robot must be located in a pressure-equalized area.

The net weight of the manipulator is approximately:

Robot Type IRB 6400R M99	Weight
2,5-120	2060 kg
2,5-150	2060 kg
2,5-200	2230 kg
2,8-150	2240 kg
2,8-200	2390 kg
3,0-100	2250 kg

The control system weighs approximately: 240 kg.

Whenever the manipulator is transported, axis 2 must be bent backwards 30° and axis 3 must be moved down to a position against the rubber stops on axis 2.

1.1 Stability / risk of tipping

When the manipulator is not fastened to the floor and standing still, the manipulator is not stable in the whole working area. When the arms are moved, care must be taken so that the centre of gravity is not displaced, as this could cause the manipulator to tip over.

The following table shows the positions where there is a risk of tipping and refers to the figures in chapter 3.8 in Product Specification IRB 6400R, for definition of position 0 and 5.

The new position does not refer to any figure. In this position, with axis 2 at an angle of -35° and axis 3 at an angle of 0°, there is no risk of the manipulator tipping.

Version	Working area pos. 0		Working area pos. 5		NEW pos.	
	load = 0 kg	load = max	load = 0 kg	load = max	load = 0kg	load = max
2,5-120	no	yes	yes	yes	no	no
2,5-150	no	yes	yes	yes	no	no
2,5-200	no	yes	yes	yes	no	no
2,8-150	no	yes	yes	yes	no	no
2,8-200	no	yes	yes	yes	no	no
3,0-100	no	yes	yes	yes	no	no

All other axes should have an angle of 0°.

no = stable
yes = risk of tipping

For Foundry (F) version, see corresponding non F-version.

1.2 System diskettes

The diskettes in the box, fixed to the shelf for the teach pendant, should be copied (in a PC) before they are used. Never work with the original diskettes. When you have made copies, store the originals in a safe place.

Do not store diskettes inside the controller due to the high temperatures there.

2 On-Site Installation

2.1 Lifting the manipulator and controller

If the integrated lifting ears on the front cannot be reached, the manipulator must be reoriented to the sync position (applicable to versions 2.8-120 and 3.0-75 only).

The best way to lift the manipulator is to use four lifting straps of similar length with hooks and a traverse crane. Attach the straps to the integrated lifting eyes on both sides of the frame (see Figure 1). The lifting strap dimensions must comply with the applicable standards for lifting. It is also possible to use two lifting devices (option) for use with a fork lift truck (see Figure 2).

The following lifting instructions are valid for a “naked” robot. Whenever additional equipment is put on the robot, the centre of gravity can change and make lifting dangerous.

Never walk under a suspended load.

.

Crane lift for:
2,5-120 / 2.5-150 / 2,5-200 / 2,8-150 / 2,8-200 / 3,0-100

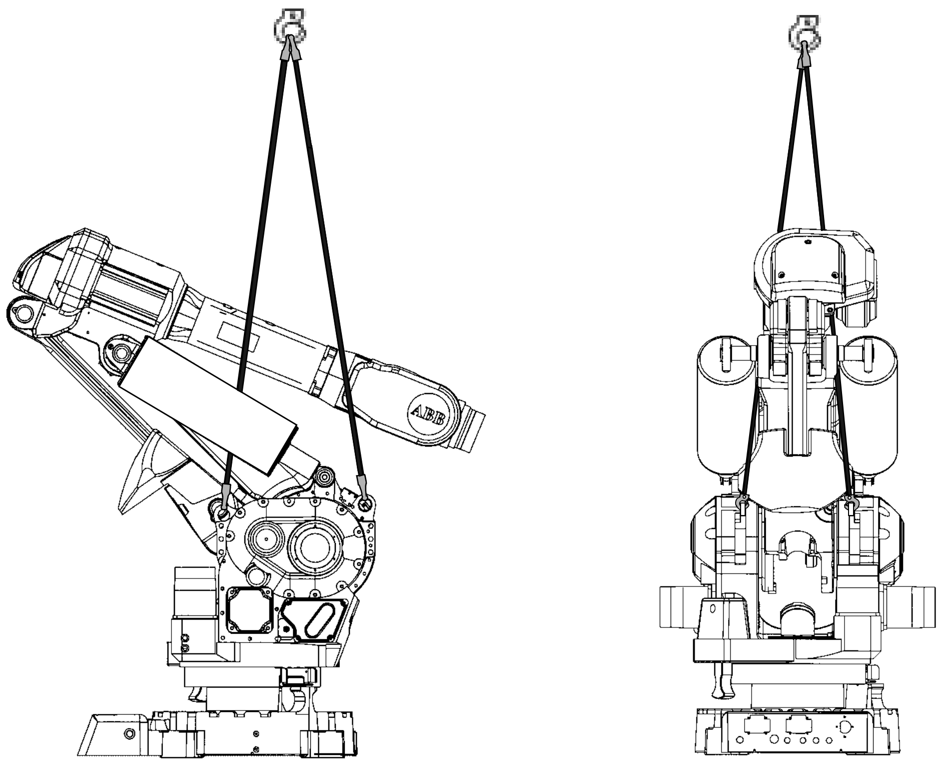


Figure 1 Lifting the manipulator using a traverse crane.

Fork lift for:
2,5-120 / 2.5-150 / 2,5-200 / 2,8-150 / 2,8-200 / 3,0-100

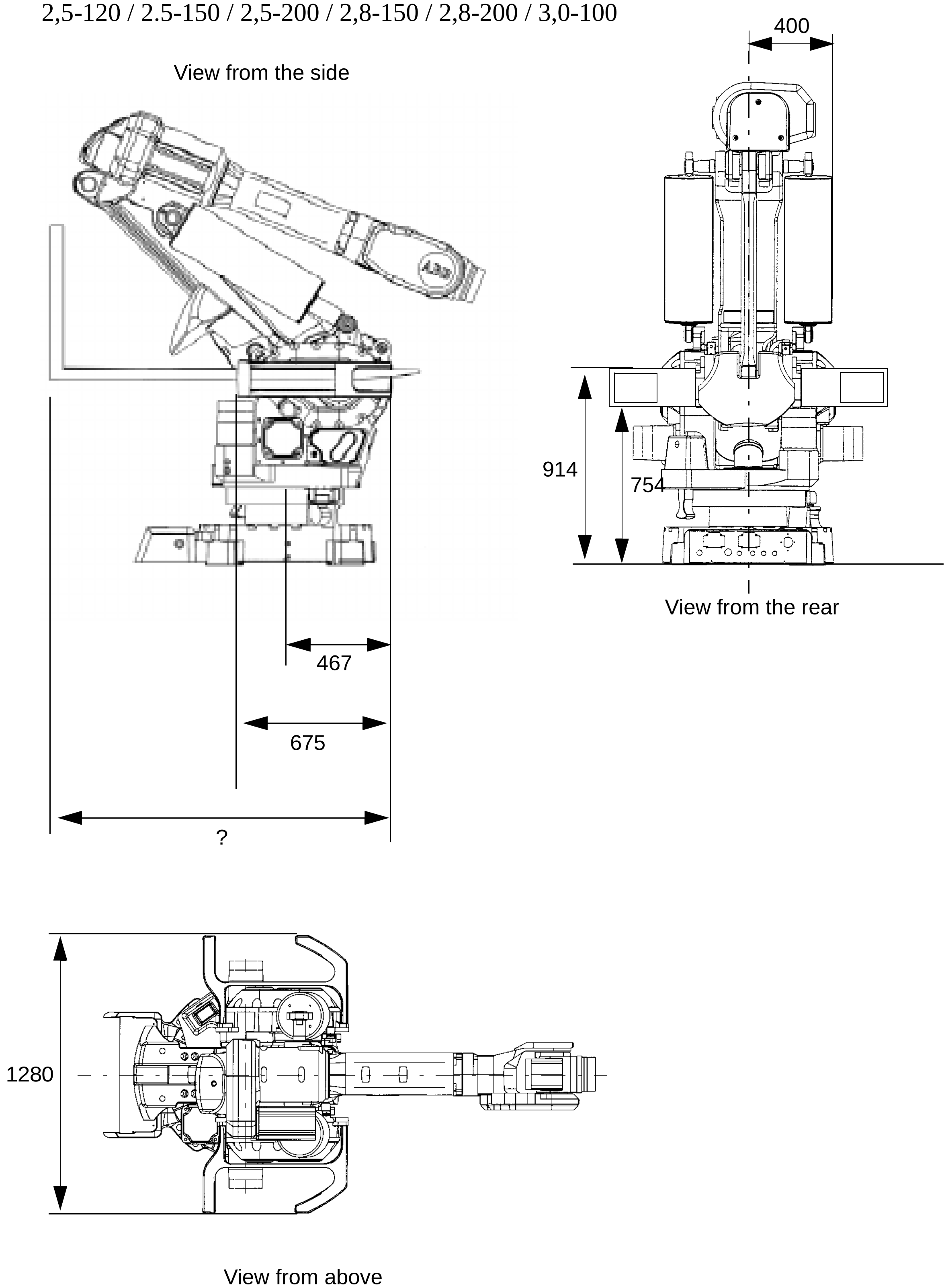


Figure 2 Lifting the manipulator using a fork lift truck.

Crane lifting is not permitted using the fork lift arrangement.

Use the four lifting devices on the cabinet or a fork lift when lifting the controller (see Figure 3).

If the controller is supplied without its top cover, lifting devices must <u>not</u> be used. A fork lift truck <u>must</u> be used instead.

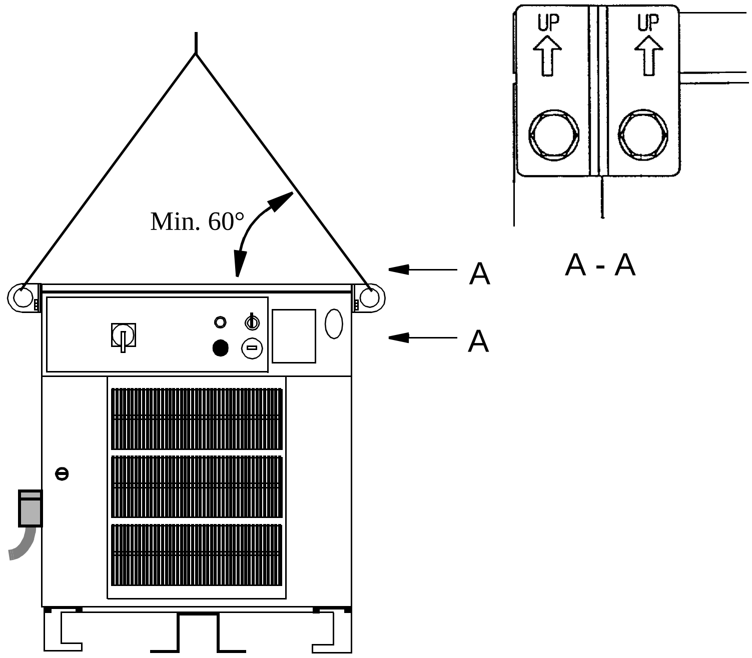
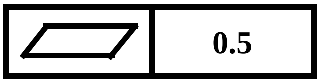


Figure 3 The maximum angle between the lifting straps when lifting the controller.

2.2 Assembling the robot

2.2.1 Manipulator

The four support points of the manipulator foot must be mounted on four flat surfaces with a flatness within the specification. Use shims if necessary. The rest of the surface must be flat within ± 2 mm. Footprint diagram, see Figure 4. Floor mounted models can be tilted max. 5º.
The levelness requirement for the surface is as follows:



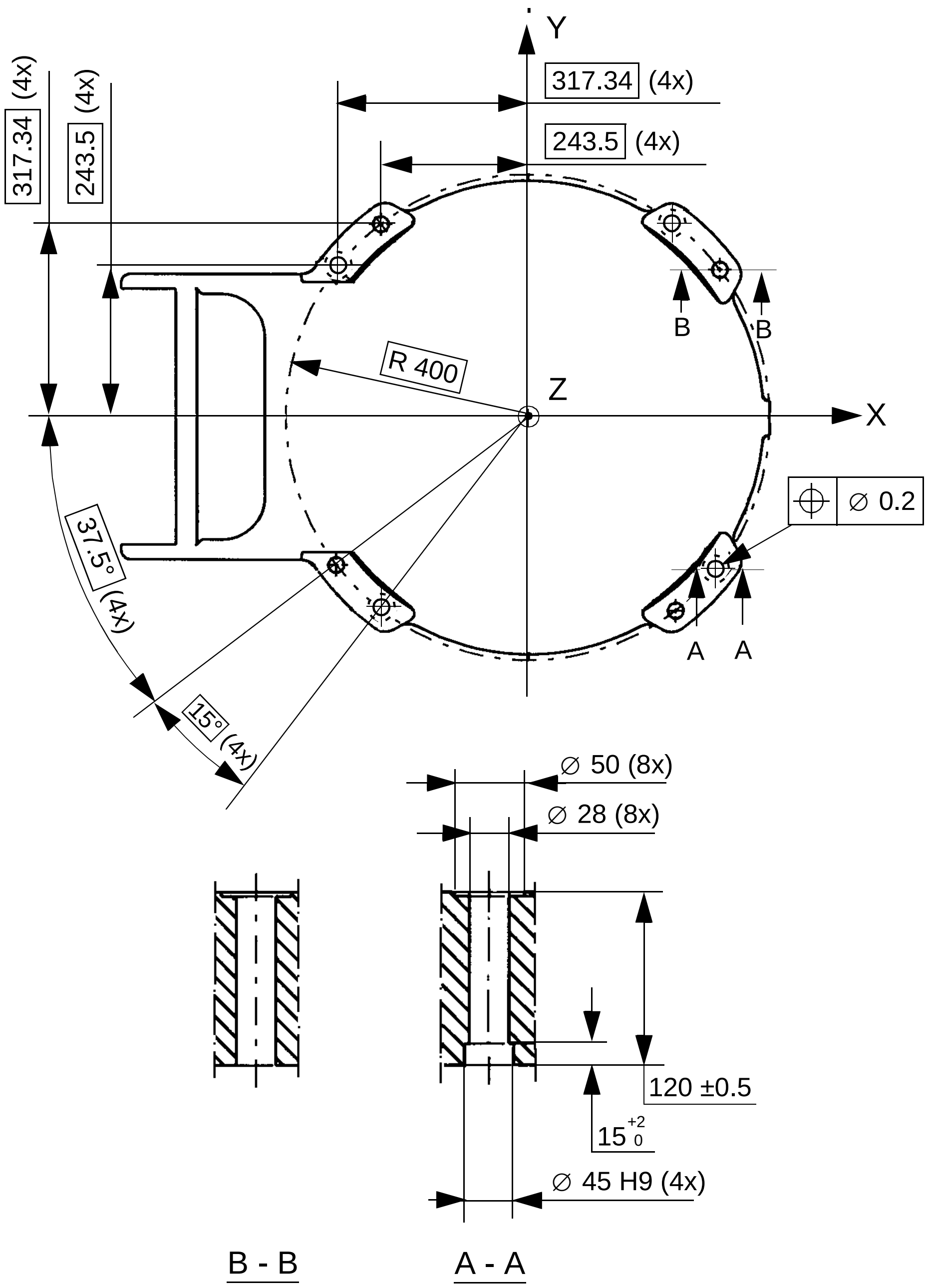


Figure 4 Bolting down the manipulator.

The manipulator is fixed with eight M24 bolts which must be tightened alternately. Note that all eight bolts must be used.

Suitable bolts:	M24x140 Socket screw
Quality	8.8
Suitable washer:	OD = 44 mm ID = 25 mm T = 4 mm
Tightening torque:	775 Nm

It is recommended that the robot is mounted with M24x140, 8.8 Socket screws (3) on two base plates (1) with four locator bushings (2), that allows the same manipulator to be re-mounted without program adjustment (see Figure 5).

For Base Plate measures (see Figure 6).

For locator bushing measures (see Figure 4).

When bolting a mounting plate or frame to a concrete floor, follow the general instructions for expansion-shell bolts. The screw joint must be able to withstand the stress loads defined in Chapter 2.3 .

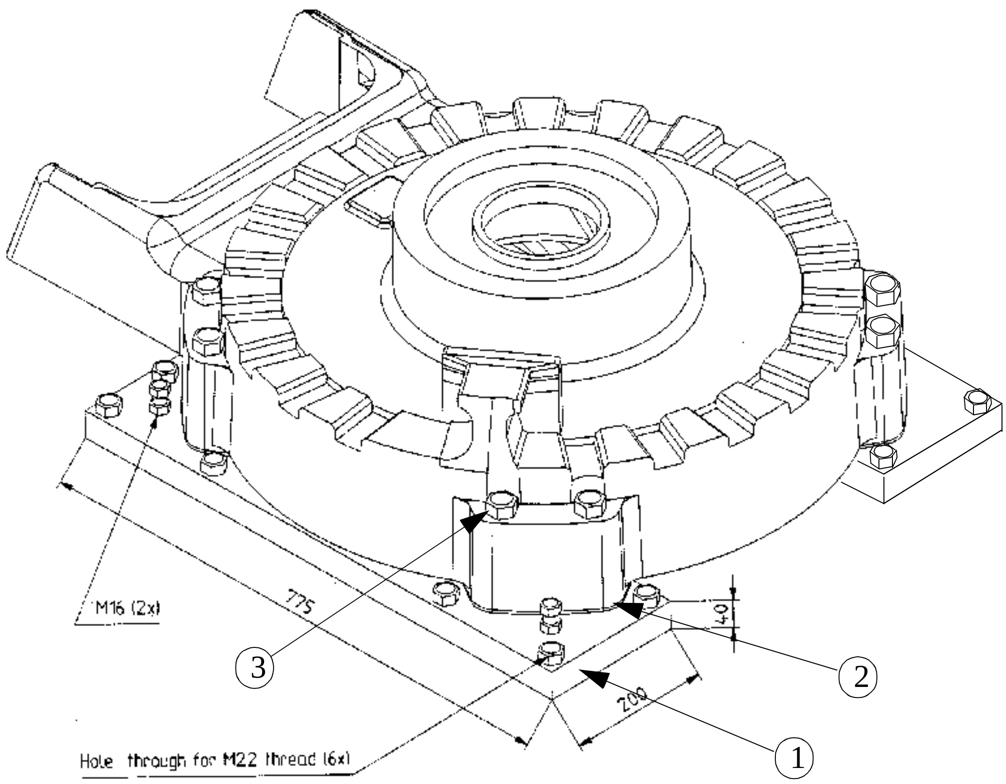


Figure 5 Base Plate.

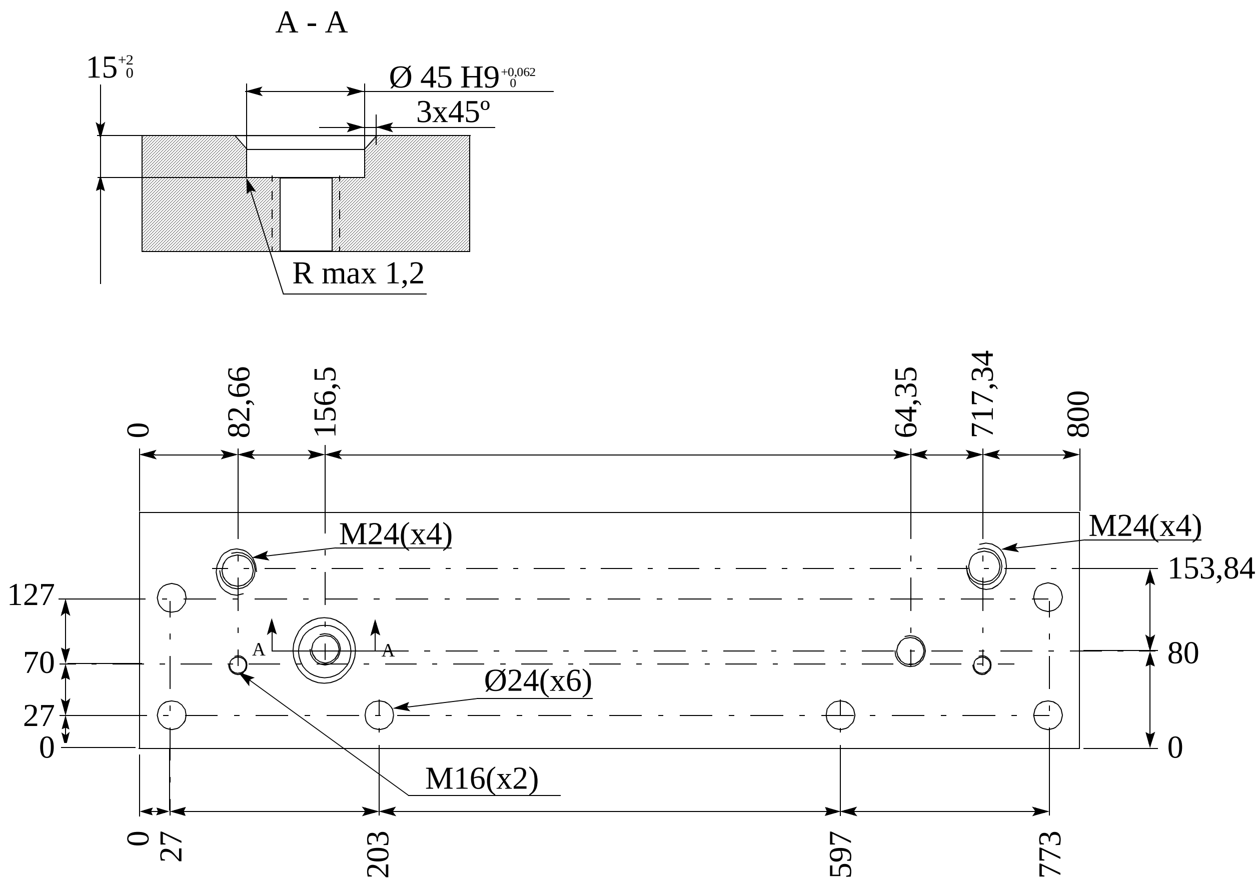


Figure 6 base Plate Measures

To orient the robot when attaching it to the floor, three guide pins can be fitted in the appropriate holes, Ø 8,5 mm (see Figure 5).

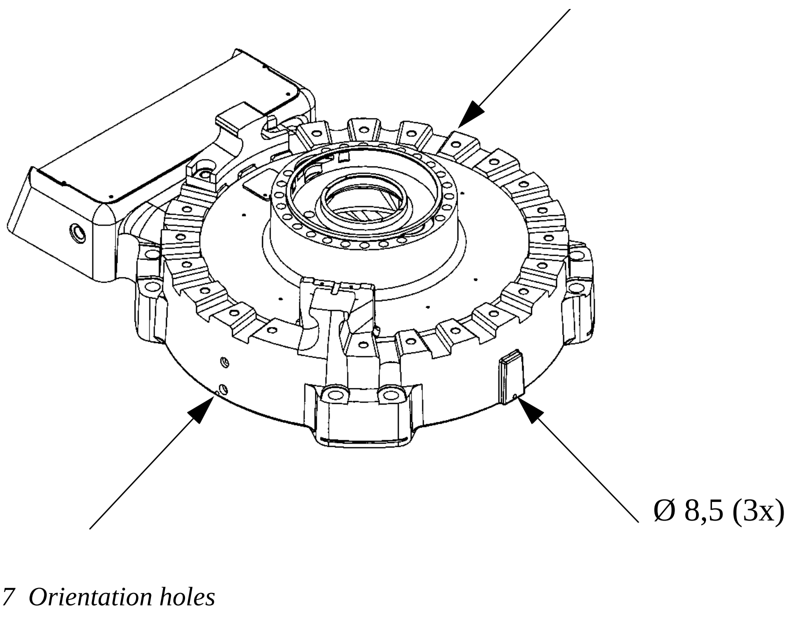
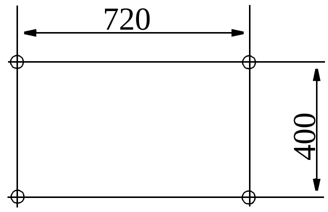


Figure 7 Orientation holes

2.2.2 Controller

The controller may be secured to the floor using M10 screws (see the footprint drawing below). See also Chapter 2.4 Amount of space required, before assembling the controller.



2.3 Stress forces

2.3.1 Stiffness

The stiffness of the foundation must be designed to minimize the influence on the dynamic behaviour of the robot. For optimal performance the frequency of the foundation with the robot weight must be higher than 22 Hz.
TuneServo can be used for adapting the robot tuning to a non-optimal foundation.

2.3.2 All versions

	Endurance load (In operation)	**Max. load (Emergency stop)**
Force xy	±14 000 N	±38 000 N
Force z	22 000 ±8 000 N	22 000 ±19 000 N
Torque xy	± 34 000 Nm	±61 000 Nm
Torque z	±7 000 Nm (±12 000 Nm*)	±15 000 Nm

Force xy and torque xy are vectors that can have any direction in the xy plane.

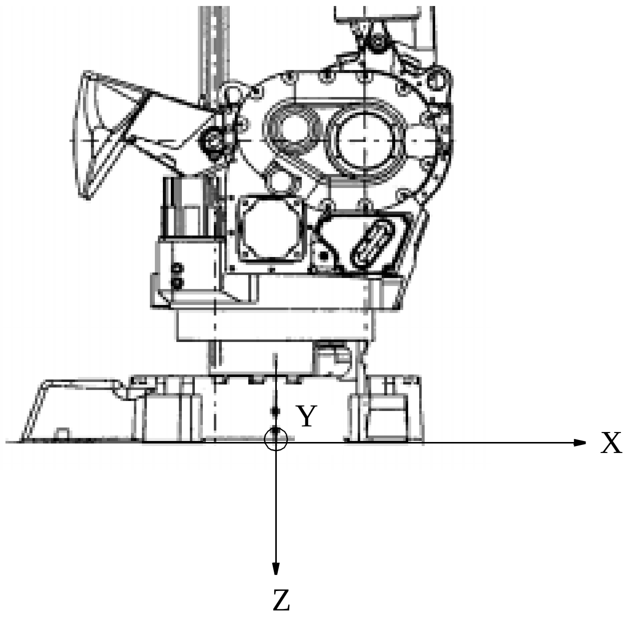


Figure 8 The directions of the stress forces.

2.4 Amount of space required

The amount of working space required to operate the manipulator and controller is illustrated in Figure 9 and Figure 10.

The working range for axis 1 is +/- 180°.

NB: There are no software or mechanical limits for the working space under the base of the manipulator.

2.4.1 Manipulator

2.5-150

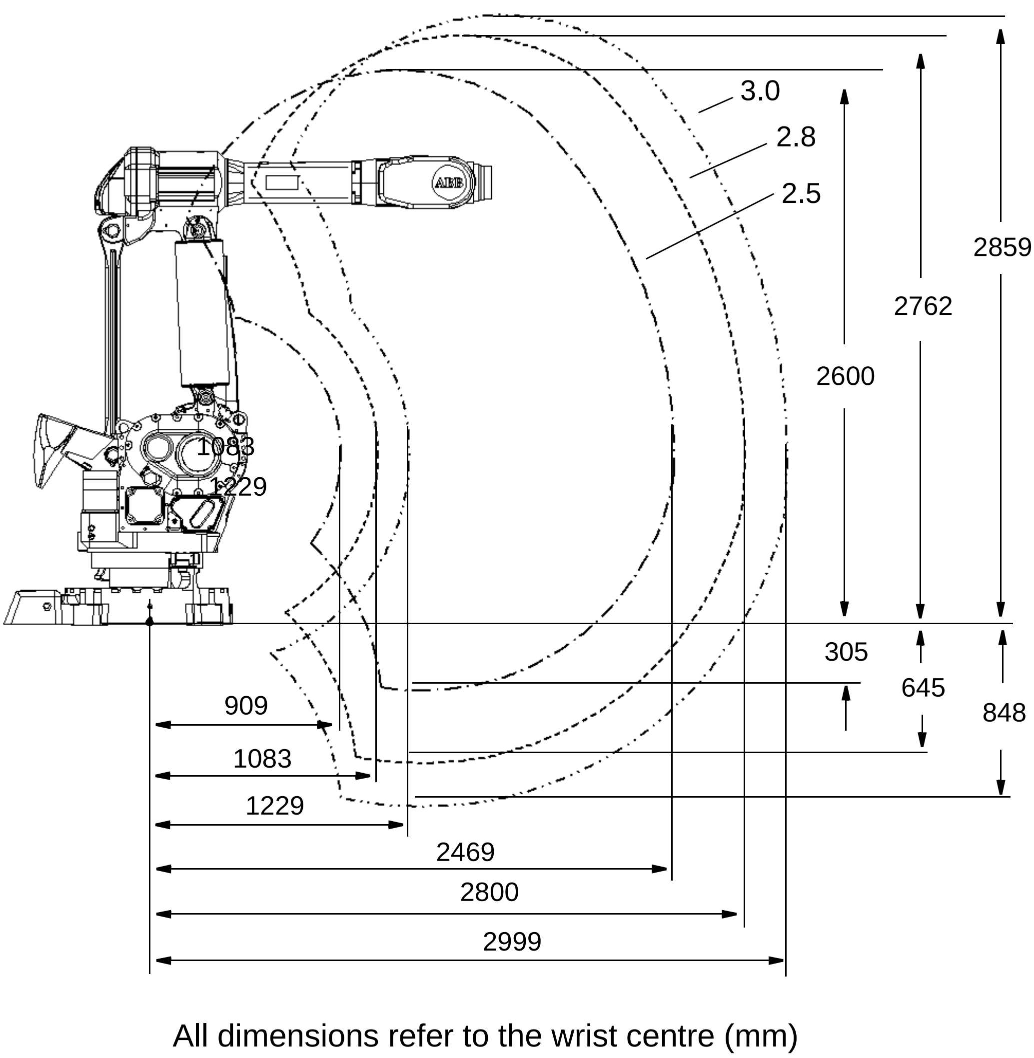


Figure 9 The working space required for the manipulator

2.4.2 Controller

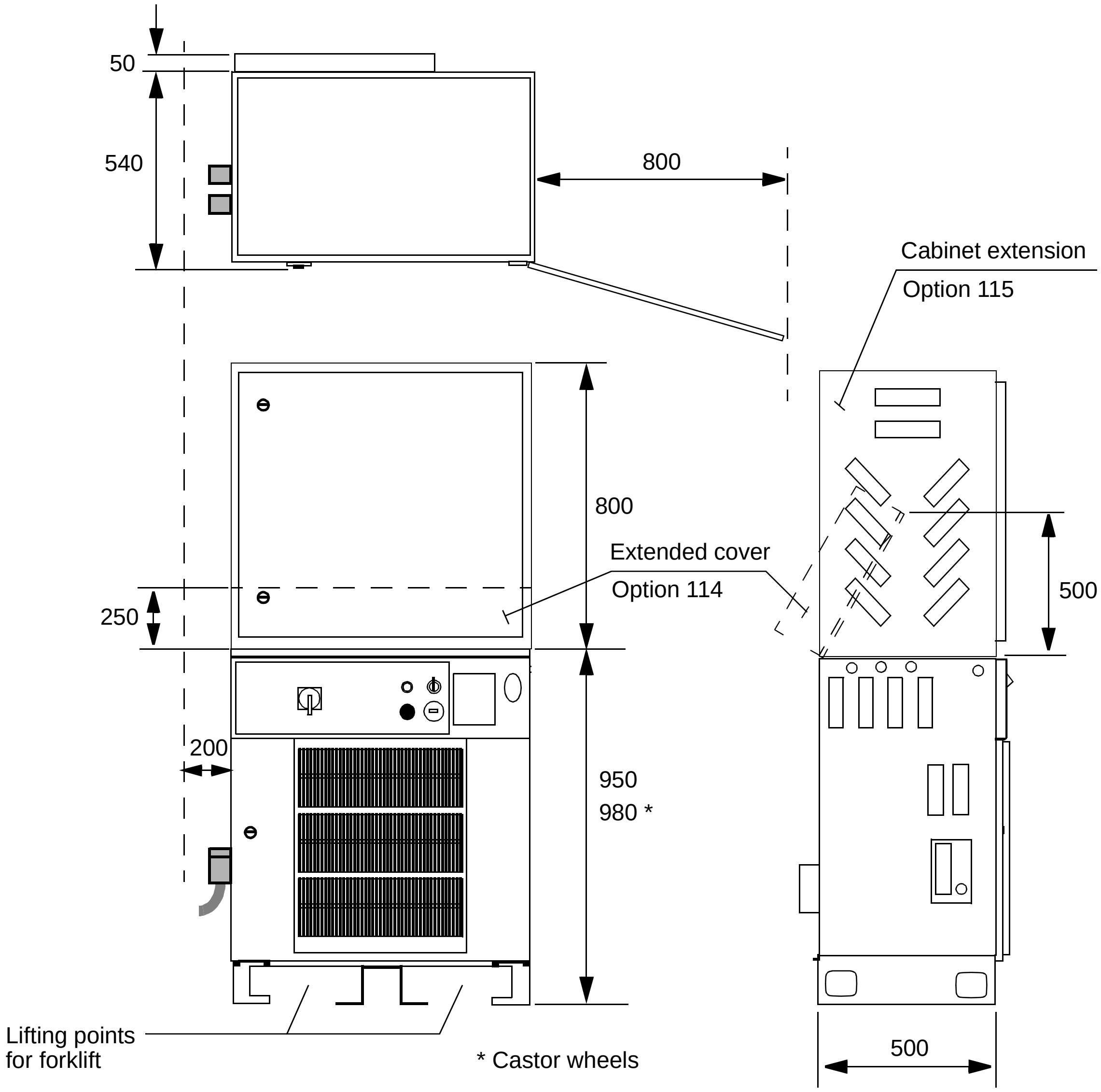


Figure 10 The space required for the controller.

2.5 Manually releasing the brakes

All axes come equipped with holding brakes. When the position of a manipulator axis needs to be changed without connecting the controller, an external voltage supply (24 V DC) must be connected to enable disengagement of the brakes. The voltage supply should be connected to the connector at the base of the manipulator (see Figure 11).

For robots with serial no. 64-15011 to 64-15015, the pins 37 (0V) and 33 (+24V) are used to supply power for releasing the brakes.

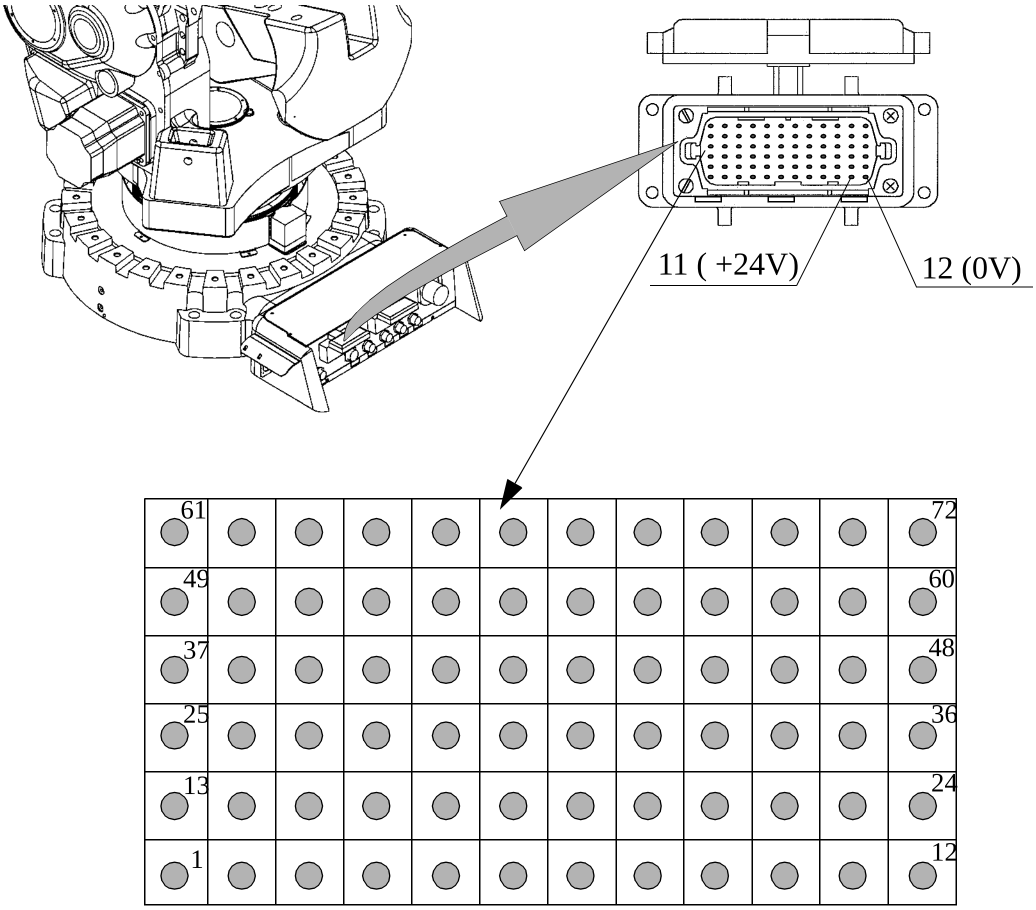


Figure 11 Connection of external voltage to enable disengagement of the brakes.

External power must be connected as shown in Figure 11. Incorrectly connected power can release all brakes, causing immediate movement of all axes.

When the controller or the voltage device is connected, as illustrated above, the brakes can be released one by one by means of the push-buttons on the brake release unit on the exterior of the axis 3 gear box. The push-buttons are marked with the appropriate axis name. The names of the axes and their motion patterns are illustrated in Figure 12.

WARNING: Be very careful when disengaging the brakes. The axes become activated very quickly and may cause damage or injury

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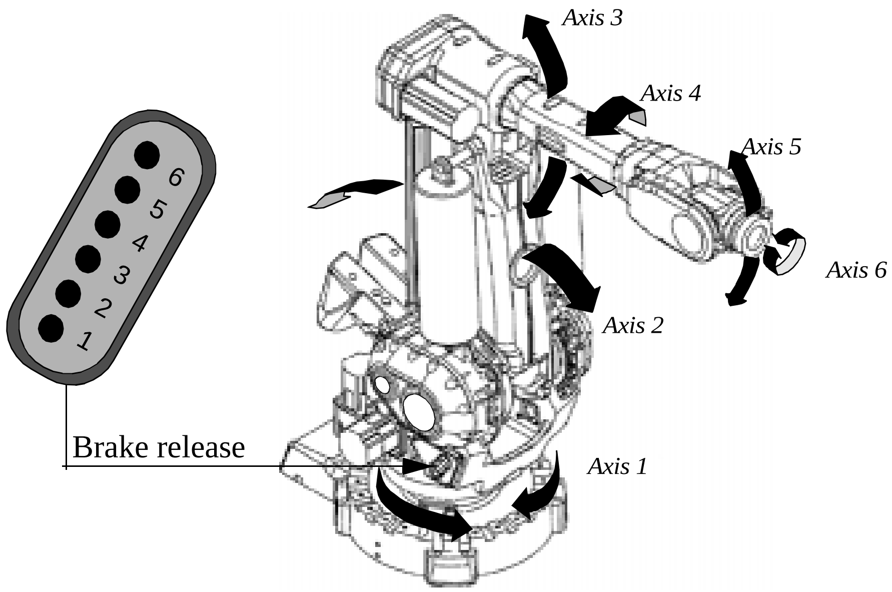


Figure 12 The robot axes and motion patterns.

2.6 Restricting the working space

When installing the manipulator, make sure that it can move freely within its entire working space. If there is a risk that it may collide with other objects, its working space should be limited, both mechanically and using software. Installation of an optional extra stop for the main axes 1, 2 and 3 is described below.

Limiting the working space using software is described in the chapter System Parameters in the User’s Guide.

If a Process Media cabling is mounted on the manipulator the area between 100° and 180° must not be used as the main working space, due to the risk of extreme warned out and shortened life span on the cabling, see Figure 13.

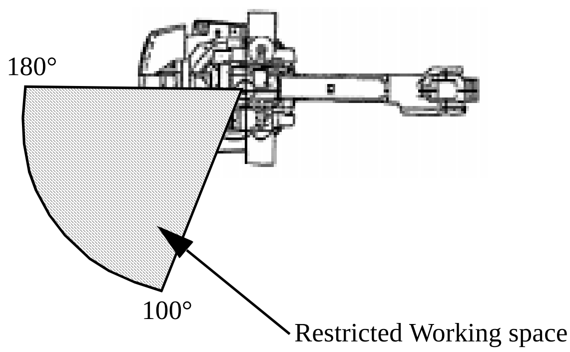


Figure 13 Restricted Work Space

2.6.1 Axis 1

The range of rotation for axis 1 can be limited mechanically by fitting extra mechanical stops, with 7.5º or 15º graduation.

Instructions for doing this are supplied with the kit.

IMPORTANT! The mechanical stop pin and the extra moveable mechanical stop arm for axis 1 must absolutely be replaced after a hard collision, if the pin or arm has been deformed.

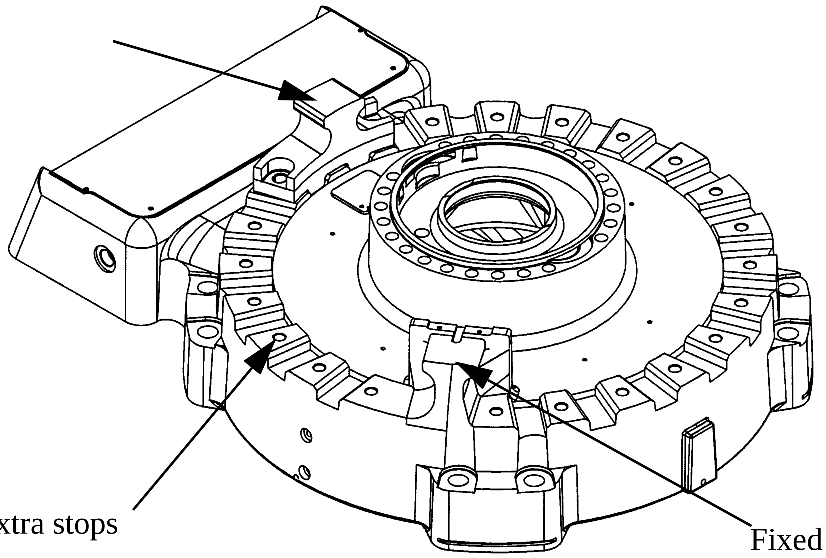


Figure 14 Mechanically limiting axes1.

2.6.2 Axes 2 and 3

The working range of axes 2 and 3 is limited by mechanical stops and can be reduced by adding up to six fixed mechanical stops with 15º graduation.

The stops are fitted on the inside of the frame to each axis.

Extra stops must be fitted in a row, starting at the fixed stop.

When fitting extra stops, the cams for the position switch should not be mounted in position.

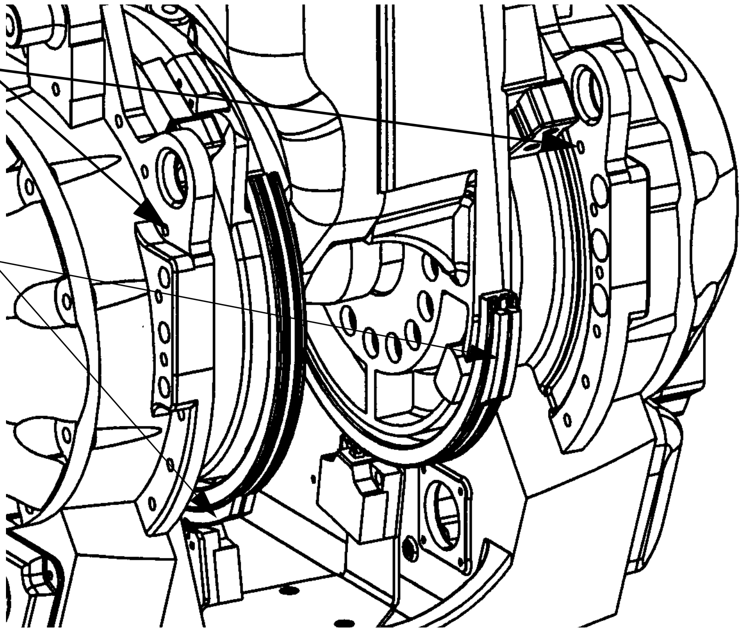


Figure 15 Mechanically limiting axes 2 and 3.

2.6.3 Position switch

There are position switches fitted on axes 1-3. Instructions for fitting and adjusting the cams and stops follow below.

The cams are mounted in whole lengths and must therefore be cut to suit the application. Use a sharp knife and a rubber hammer, for example.

It is important that the entry edge on the cam is chamfered to an angle of max. 30°. If the angle is larger there is a risk of damaging the position switch (see Figure 16).

The ends of the cam, that are in the channel of the profile, must be cut at an angle of 90° so that the contact area for the stop is as large as possible (see Figure 17).

When fitting the cam, it is important that the edges on the openings at the ends of the profile are properly chamfered.

The cam stop comprises an M5 nut with an M5 x 6 stop screw. When the screw is tighten into the material at the bottom of the profile, the nut is pushed up to the top of the channel and forms a lock for the cam (see Figure 17).

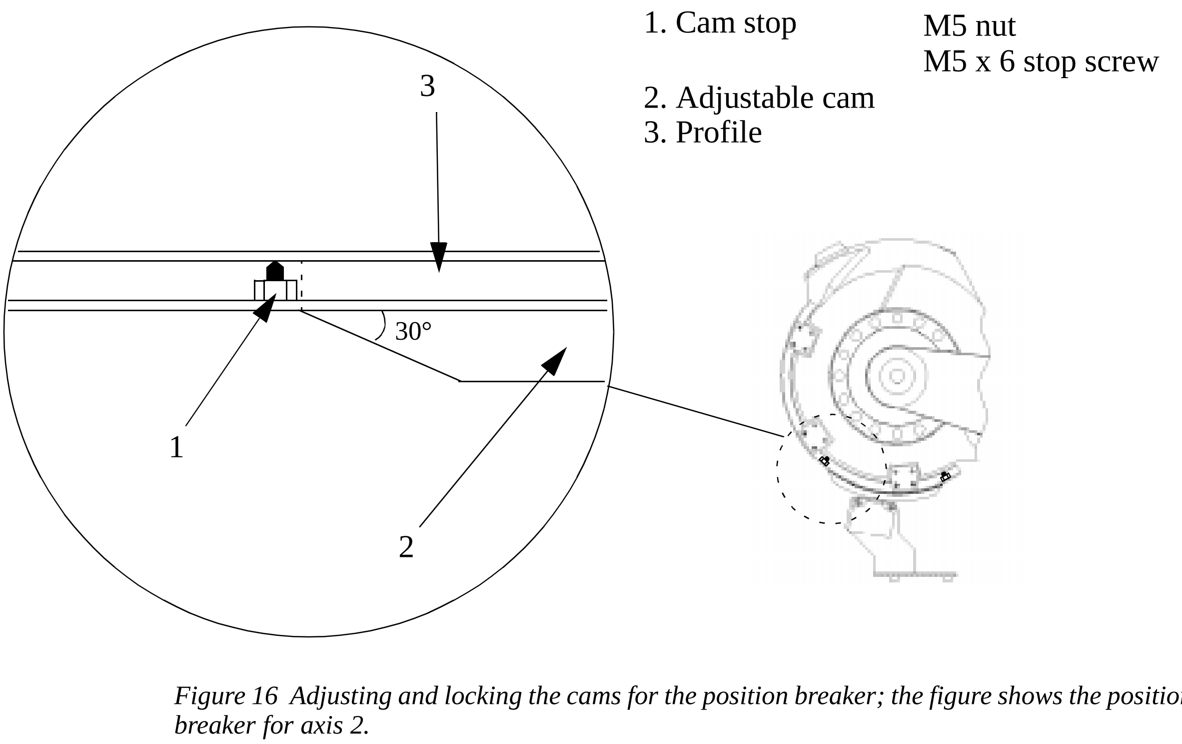


Figure 16 Adjusting and locking the cams for the position breaker; the figure shows the position breaker for axis 2.

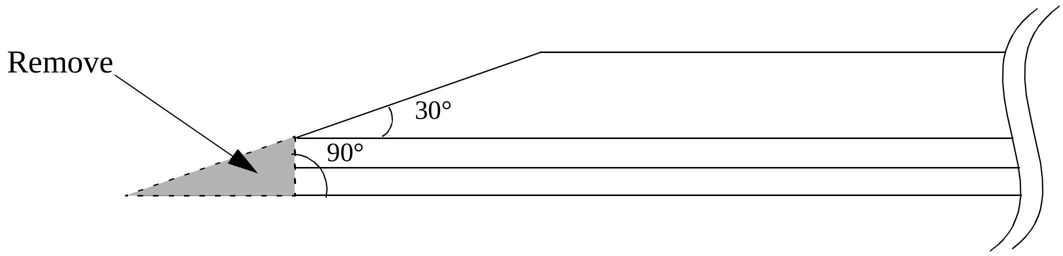


Figure 17 Cutting the cam.

2.7 Mounting holes for equipment on the manipulator

NB: Never drill a hole in the manipulator without first consulting maintenance staff or the design department at ABB Flexible Automation.

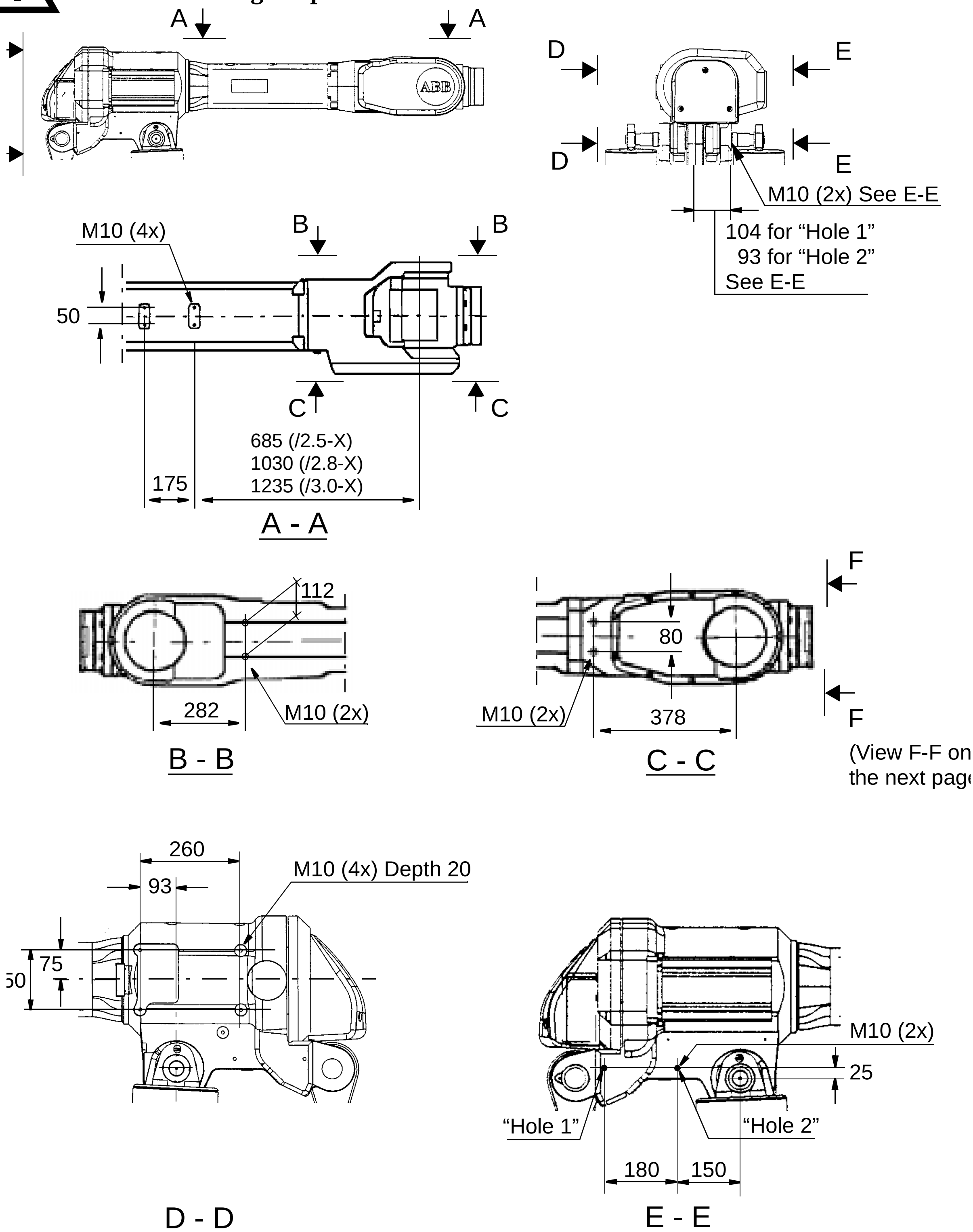


Figure 18 Holes for mounting extra equipment (dimensions in mm).

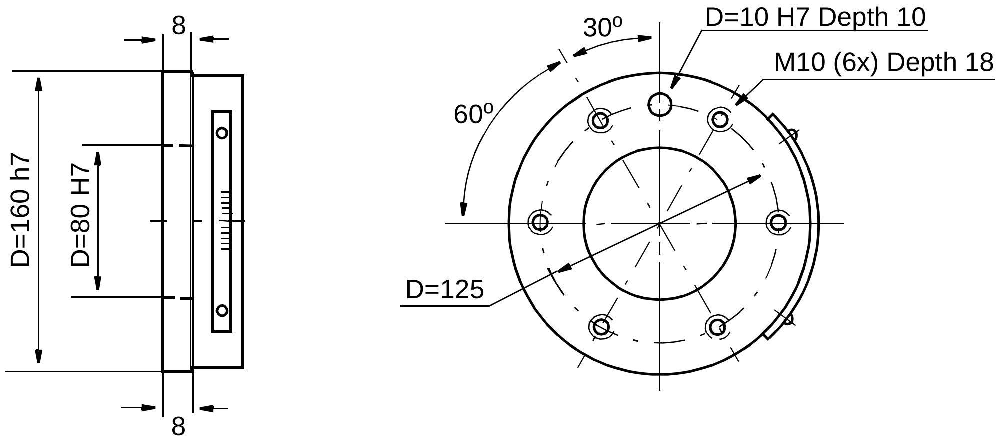


Figure 19 The mechanical interface (mounting flange) ISO 9409 (dimensions in mm).

2.7.1 Quality of screws for fitting extra equipment

When fitting tools on the manipulator's mounting flange (see above), use only screws with quality of 12.9. When fitting other equipment, standard screws with quality 8.8 can be used.

2.8 Loads

It is important to define the loads properly (with regard to the position of centre of gravity and inertia factor) in order to avoid jolting movements and unnecessary stops due to overloaded motors.

For more information see chapter 3.4 in Product Specification IRB 6400R (Technical specification) for load diagrams, permitted extra loads (equipment) and their positions. The loads must also be defined in the software, see User´s Guide.

2.8.1 Break Times

For information about Brake Times, please contact SEROP Support.

2.9 Connecting the controller to the manipulator

Two cables are used to connect the controller to the manipulator, one for measuring signals and the other for motor and brakes.

The connection on the manipulator is located on the rear of the robot base.

2.9.1 Connection on left-hand side of cabinet

The cables are connected to the left side of the cabinet using an industrial connector and a Burndy connector (see Figure 20). A connector is designated XP when it has pins (male) and XS when it has sockets (female). A screwed connection is designated XT.

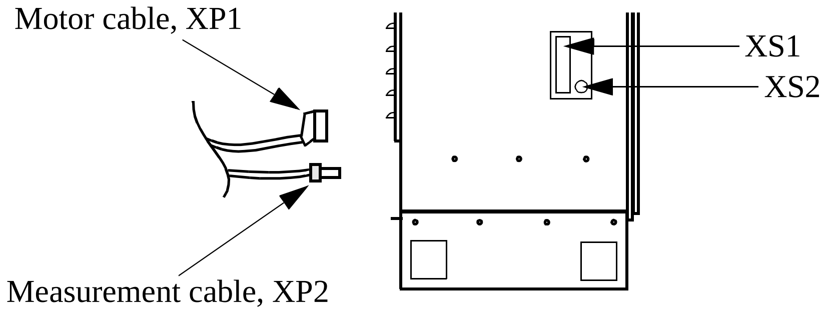


Figure 20 Connections on the cabinet wall.

2.10 Dimensioning the safety fence

A safety fence must be fitted around the robot to ensure a safe robot installation. The fence must be dimensioned to withstand the force created if the load being handled by the robot is dropped or released at maximum speed. The maximum speed is determined from the max. velocities of the robot axes and from the position at which the robot is working in the workcell. See Product Specification, section 3.8. The max. speed for a load mounted on the IRB 6400R is 8 m/s.

2.11 Mains power connection

Before starting to connect the mains, make sure that the other end of the cable is disconnected from the line voltage.

The power supply can be connected either inside the cabinet, or to a optional socket on the left-hand side of the cabinet or the lower section of the front. The cable connector is supplied but not the cable. The mains supply cables and fuses should be dimensioned in accordance with rated power and line voltage, see rating plate on the controller.

2.11.1 Connection to the mains switch

Remove the left cover plate under the top lid. Pull the mains cable (outer diam. 10.20 mm) through the gland (see Figure 21), located on the left cabinet wall.

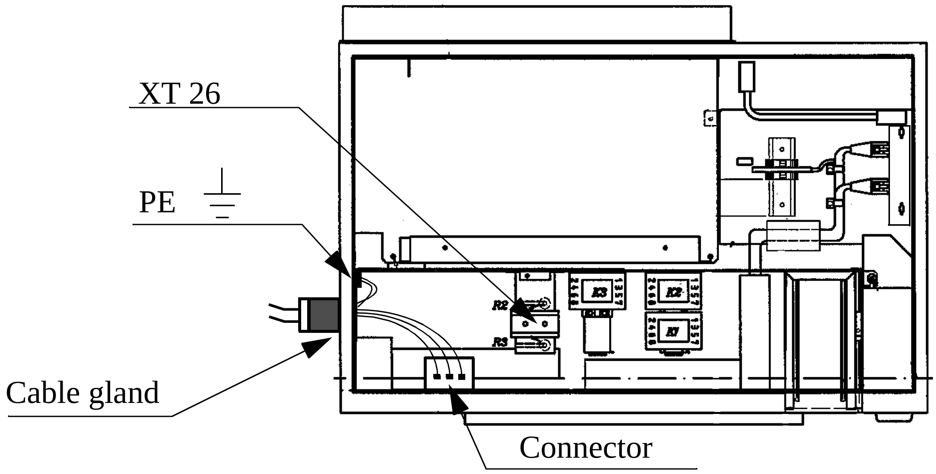


Figure 21 Mains connection inside the cabinet.

Connect as below (also see chapter 11, Circuit Diagram.):

1. Release the connector from the knob by pressing in the red button located on the upper side of the connector (see Figure 21).

2. Connect phase 1 to L1 (N.B. Not dependent on phase sequence)
   2 to L2
   3 to L3
   0 to XT26.N(line neutral is needed only for option 432)

   and protective earth to ⏚

   NOTE!
   Max. cunductor size is 6 mm² (AWG 10). Tighten torque 2.3-2.5 Nm.
   Retighten after approx. 1 week.

3. Snap the breaker on to the knob again and check that it is fixed properly in the right position.

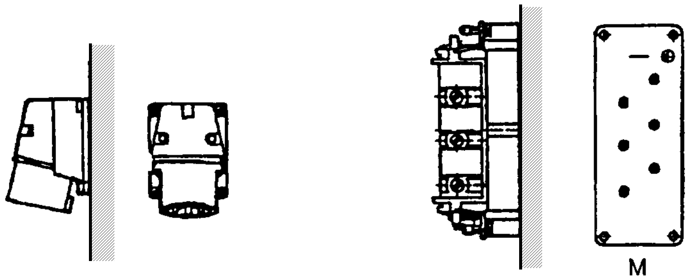
4. Tighten the cable gland.

5. Fasten the cover plate.

2.11.2 Connection via a power socket

You can also connect the mains supply via an optional wall socket of type CEE 3x16 and 3x32 A, or via an industrial Harting connector (DIN 41 640). See Figure 22.

Cable connectors are supplied (option 133 - 134).



CEE connector DIN connector

Figure 22 Mains connection via an optional wall socket.

2.12 Inspection before start-up

Note! The controller is not to be moved when it is powered on, due to the risk off seriously damaging the hard disk.

Before switching on the power supply, check that the following have been performed:

1. The robot has been properly mechanically mounted and is stable
2. The controller mains section is protected with fuses.
3. The electrical connections are correct and corresponds to the identification plate on the controller.
4. The teach pendant and peripheral equippment are properly connected.
5. That limiting devices that establish the restricted space (when utilized) are installed.
6. The physical environment is as specified.
7. The operating mode selector on the operator’s panel is in Manual mode position.

When external safety devices are used check that these have been connected or that the following circuits in either **XS3** (connector on the outside left cabinet wall) or **X1-X4** (screw terminals on the panel unit) are strapped:

	XS3	Panel unit
External limit switches	A5-A6, B5-B6	X1.3-4, X2.3-4
External emergency stop	A3-A4, B3-B4	X1.9-10, X2.9-10
External emergency stop, internal 24 V	A1-A2, B1-B2	X1.7-8, X2.7-8
General stop +	A11-A12, B11-B12	X3.10-12, X4.10-12
General stop -	A13-A14, B13-B14	X3.7-8, X4.7-8
Auto stop +	A7-A8, B7-B8	X3.11-12, X4.11-12
Auto stop -	A9-A10, B9-10	X3.7-9, X4.7-9
Motor off clamping	A15-A16, B15-16	X1.5-6, X2.5-6

For more information, see Chapter 3.8, The MOTORS ON / MOTORS OFF circuit and Chapter 3.9, Connection of safety chains.

2.13 Start-up

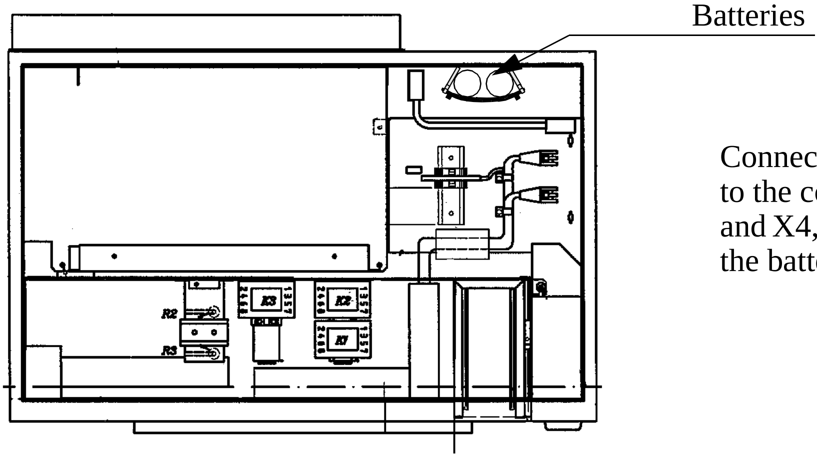
2.13.1 General

1. Switch on the mains switch on the cabinet.

2. The robot performs its self-test on both the hardware and software. This test takes approximately 1 minute.

   If the robot is supplied with software already installed, proceed to pos. 3 below. Otherwise continue as follows (no software installed):

   - Connect the batteries for memory backup (see Figure 23).
   - Install the software as described in Chapter 4, Installing the Control Program.



Connect the batteries to the connectors X3 and X4, situated below the batteries.

Figure 23 Location of batteries, view from above.

3. A welcome message is shown on the teach pendant display.

4. To switch from MOTORS OFF to MOTORS ON, press the enabling device on the teach pendant.

5. Update the revolution counters according to 2.13.2.

6. Check the calibration position according to section 2.13.3.

7. When the controller with the manipulator electrically connected are powered up for the first time, ensure that the power supply is connected for at least 36 hours continuously, in order to fully charge the batteries for the serial measurement board.

   After having checked the above, verify that

8. the start, stop and mode selection (including the key lock switches) control devices function as intended.

9. each axis moves and is restricted as intended.

10. emergency stop and safety stop (where included) circuits and devices are functional.

11. it is possible to disconnect and isolate the external power sources.

12. the teach and playback facilities function correctly.

13. the safeguarding is in place.

14. in reduced speed, the robot operates properly and has the capability to handle the product or workpiece, and

15. in automatic (normal) operation, the robot operates properly and has the capability to perform the intended task at the rated speed and load.

16. The robot is now ready for operation.

2.13.2 Updating the revolution counter

When pressing the enabling device on a new robot, a message will be displayed on the teach pendant telling you that the revolution counters are not updated. When such a message appears, the revolution counter of the manipulator must be updated using the calibration marks on the manipulator (see Figure 28).

Examples of when the revolution counter must be updated:

- when one of the manipulator axes has been manually moved with the controller disconnected.
- when the battery (on the manipulator) is discharged.
  (it takes 36 hours with the mains switch on to recharge the battery)
- when there has been a resolver error
- when the signal between the resolver and the measuring panel unit has been interrupted

WARNING:
Working inside the robot working range is dangerous.

Press the enabling device on the teach pendant and, using the joystick, manually move the robot so that the calibration marks lie within the tolerance zone (see Figure 28).

When all axes have been positioned as above, the revolution counter settings are stored using the teach pendant, as follows:

1. Press the **Misc.** window key (see Figure 24).

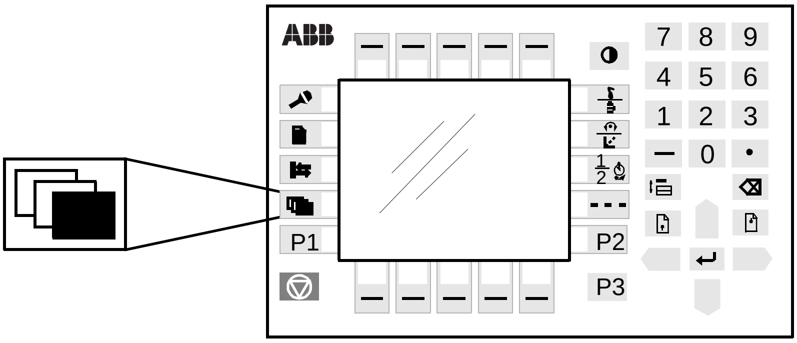


Figure 24 The Misc. window key from which the Service window can be chosen.

2. Select **Service** in the dialog box shown on the display.
3. Press Enter .
4. Then, choose **View: Calibration**. The window in Figure 25 appears.

```
   File     Edit     View    Calib
 Service Calibration

 Unit                        Status
                                         1(1)
  IRB                   Not rev. counter update
```

Figure 25 This window shows the status of the revolution counters.

If there are several units connected to the robot, these will be listed in the window.

5. Select the desired unit in the window, as in Figure 25. Choose **Calib: Rev. Counter Update**. The window in Figure 26 appears.

```
 Rev. Counter Update!
 IRB
 To calibrate, include axes and press OK.

      Axis                 Status
                                         1(6)
  X      1       Not updated Rev. Counter
  X      2       Not updated Rev. Counter
         3       Calibrated
         4       Calibrated
  X      5       Not updated Rev. Counter
  X      6       Not updated Rev. Counter

    Incl     All             Cancel     OK
```

Figure 26 The dialog box used to select axes whose revolution counters are to be updated.

6. Press the function key ***All*** to select all axes if all axes are to be updated. Otherwise, select the desired axis and press the function key ***Incl*** (the selected axis is marked with an x).

7. Confirm by pressing ***OK***. A window like the one in Figure 27 appears.

```
Rev. Counter Update!
IRB

The Rev. Counter for all marked axes
will be update.
It cannot be undone.

OK to continue?

                         Cancel    OK
```

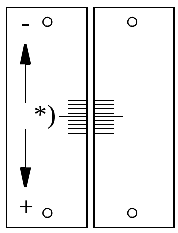
Figure 27 The dialog box used to start updating the revolution counter.

8. Start the update by pressing ***OK***.

If a revolution counter is incorrectly updated, it will cause incorrect positioning. Thus, check the calibration very carefully after each update. Incorrect updating can damage the robot system or injure someone.

9. Check the calibration as described in Chapter 2.13.3, Checking the calibration position.

10. Save the system parametrs on floppy disk.



*) axis number

Figure 28 Calibration marks on the manipulator.

2.13.3 Checking the calibration position

There are two ways to check the calibration position and they are described below.

Using the diskette, Controller Parameters:

Run the program \ SERVICE \ CALIBRAT \ CAL 6400 on the diskette, follow intructions displayed on the teach pendant. When the robot stops, switch to MOTORS OFF. Check that the calibration marks for each axis are at the same level, see Figure 28. If they are not, the setting of the revolution counters must be repeated.

Using the Jogging window on the teach pendant:

Open the Jogging window  and choose running axis-by-axis. Using the joystick, move the robot so that the read-out of the positions is equal to zero. Check that the calibration marks for each axis are at the same level, see Figure 28. If they are not, the setting of the revolution counters must be repeated.

2.13.4 Alternative calibration positions

See chapter 12, Repairs.

2.13.5 Operating the robot

Starting and operating the robot is described in the User's Guide. Before start-up, make sure that the robot cannot collide with any other objects in the working space.

3 Connecting Signals

3.1 Signal classes

Power – supplies external motors and brakes.

Control signals – digital operating and data signals (digital I/O, safety stops, etc.).

Measuring signals – analog measuring and control signals (resolver and analog I/O).

Data communication signals – Gateway (Field bus) connection, computer link.

Different rules apply to the different classes when selecting and laying cable. Signals from different classes must not be mixed.

3.2 Selecting cables

All cables laid in the controller must be capable of withstanding 70^{o} C. In addition, the following rules apply to the cables of certain signal classes:

Power signals -Shielded cable with an area of at least 0.75 mm^2 or AWG 18. Note that any local standards and regulations concerning insulation and area must always be complied with.

Control signals – Shielded cable.

Measuring signals – Shielded cable with twisted pair conductors.

Data communication signals – Shielded cable with twisted pair conductors. A specific cable should be used for Gateway (Field bus) connections.

CAN bus with DeviceNet for distributing I/O units;

Thin cable according to DeviceNet specification release 1.2, must be used, e.g. ABB article no. 3HAB 8277-1. The cable is screened and has four conductors, two for electronic supply and two for signal transmission.
Note that a separate cable for supply of I/O load is required.

Allen-Bradley Remote I/O;

Cables according to Allen-Bradley specification, e.g. “Blue hose”, should be used for connections between DSQC 350 and the Allen-Bradley PLC bus.

Interbus-S:

Cables according to Phönix specification, e.g. “Green type”, should be used for connections between the DSQC 351 and external Interbus-S bus.

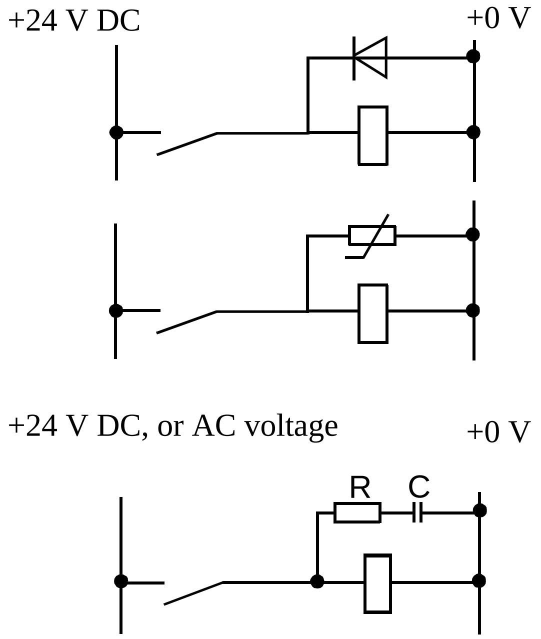
Profibus DP:

Cables according to Profibus DP specification should be used for connections between the I/O unit DSQC 352 and the external Profibus DP bus.

3.3 Interference elimination

Internal relay coils and other units that can generate interference inside the controller are neutralised. External relay coils, solenoids, and other units must be clamped in a similar way. Figure 29 illustrates how this can be done.

Note that the turn-off time for DC relays increases after neutralisation, especially if a diode is connected across the coil. Varistors give shorter turn-off times. Neutralising the coils lengthens the life of the switches that control them.



The diode should be dimensioned for the same current as the relay coil, and a voltage of twice the supply voltage.

The varistor should be dimensioned for the same energy as the relay coil, and a voltage of twice the supply voltage.

R 100 ohm, 1W
C 0.1 - 1 μF
> 500 V max voltage
125 V nominal voltage

Figure 29 Examples of clamping circuits to suppress voltage transients.

3.4 Connection types

I/O, external emergency stops, safety stops, etc., can be supplied on screwed connections or as industrial connectors.

Designation	
X(T)	Screwed terminal
XP	Male (pin)
XS	Sockets (female)

3.5 Connections

Detailed information about connection locations and functions will be found in chapter 11, Circuit Diagram.

3.5.1 To screw terminal

Panel unit and I/O units are provided with keyed screw terminals for cables with an area between 0.25 and 1.5 mm^2. A maximum of two cables may be used in any one connection. The cable screen must be connected to the cabinet wall using EMC. It should be noted that the screen must continue right up to the screw terminal.
The installation should comply with the IP54 (NEMA 12) protective standard.

Bend unused conductors backwards and attach them to the cable using a clasp, for example. In order to prevent interference, ensure that such conductors are not connected at the other end of the cable (antenna effect). In environments with much interference, disconnected conductors should be grounded (0 V) at both ends.

3.5.2 To connectors (option)

Industrial connectors with 4x16 pins for contact crimping (complies with DIN 43652) can be found on the left-hand side or front of the cabinet (depending on the customer order) See Figure 30 and Figure 21.

In each industrial connector there is space for four rows of 16 conductors with a maximum conductor area of 1.5 mm^2. The pull-relief clamp must be used when connecting the shield to the case.

The manipulator arm is equipped with round Burndy/Framatome connectors (customer connector not included).

Bend unused conductors backwards and attach them to the cable using a clasp, for example. In order to prevent interference, ensure that such conductors are not connected at the other end of the cable (antenna effect). In environments with much interference, disconnected conductors should be grounded (0 V) at both ends.

When contact crimping industrial connectors, the following applies:

Using special tongs, press a pin or socket on to each non-insulated conductor.
The pin can then be snapped into the actual contact.
Push the pin into the connector until it locks.

Also, see instructions from contact supplier.

A special extractor tool must be used to remove pins from industrial connectors.

When **two** conductors must be connected to the same pin, both of them are pressed into the same pin. A **maximum** of **two** conductors may be pressed into any one pin.

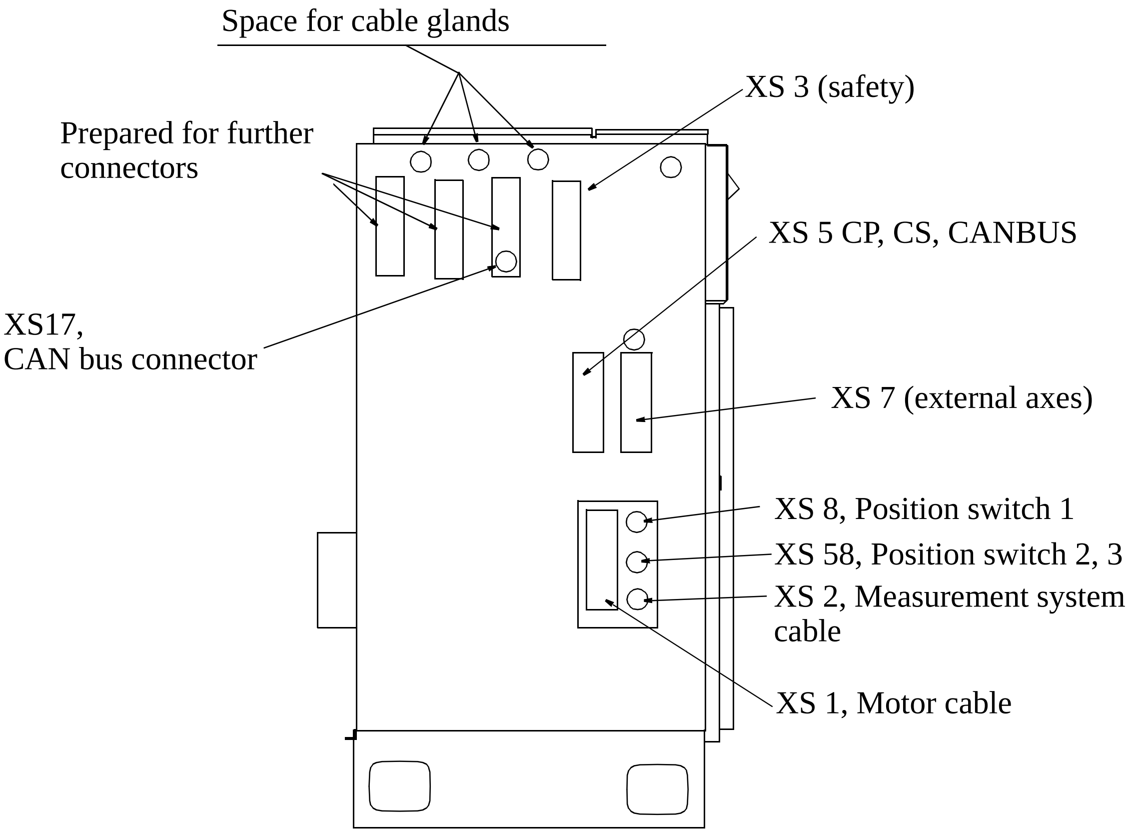


Figure 30 Positions for connections on the left-hand side of the controller.

3.6 Customer connections on manipulator

The hose for compressed air is integrated into the manipulator. There is an inlet at the base and an outlet on the upper arm housing or on the movable part of the upper arm. Connection: G 1/2” on the upper arm and G 1/2” at the base.

For connection of extra equipment on the manipulator, there are cables running parallel to the manipulator’s cable harness with one Burndy 12-pin UTD 71412 SHT and one Burndy 4-pin UTD 7104 SHT connector on the movable part of the upper arm and arm housing.

Number of signals with CANBUS: 10 signals (50 V, 250 mA), 2 power signals (250 V, 8 A).

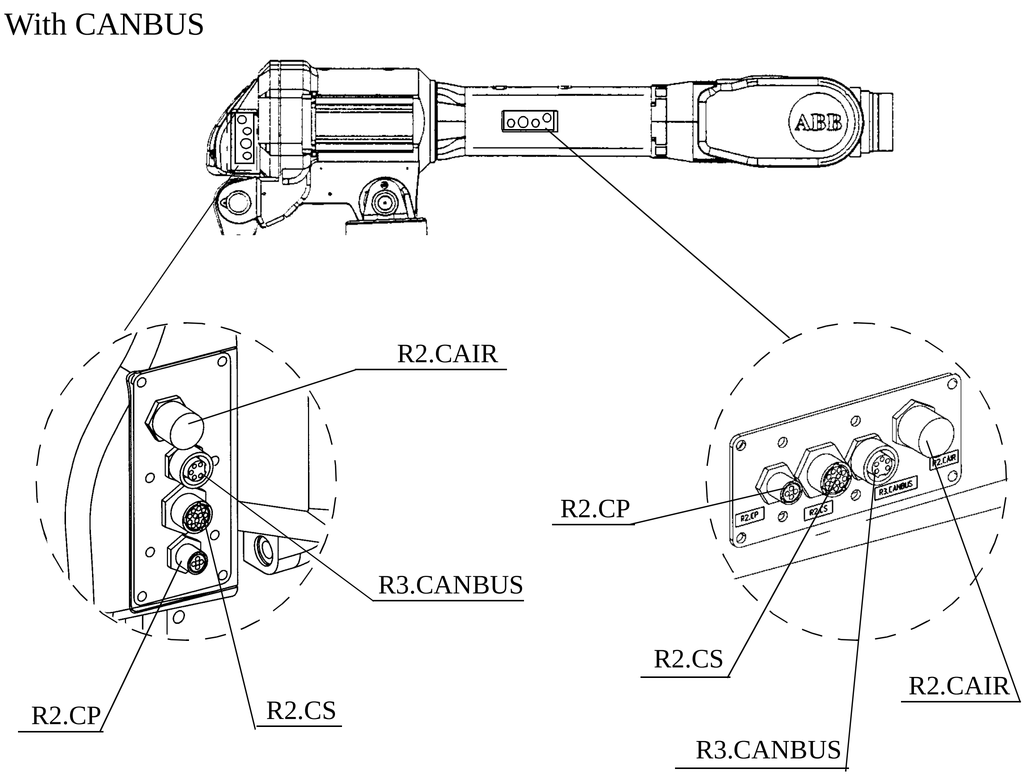


Figure 31 Location of customer connections on upper arm / arm housing.

With INTERBUS-S / PROFIBUS

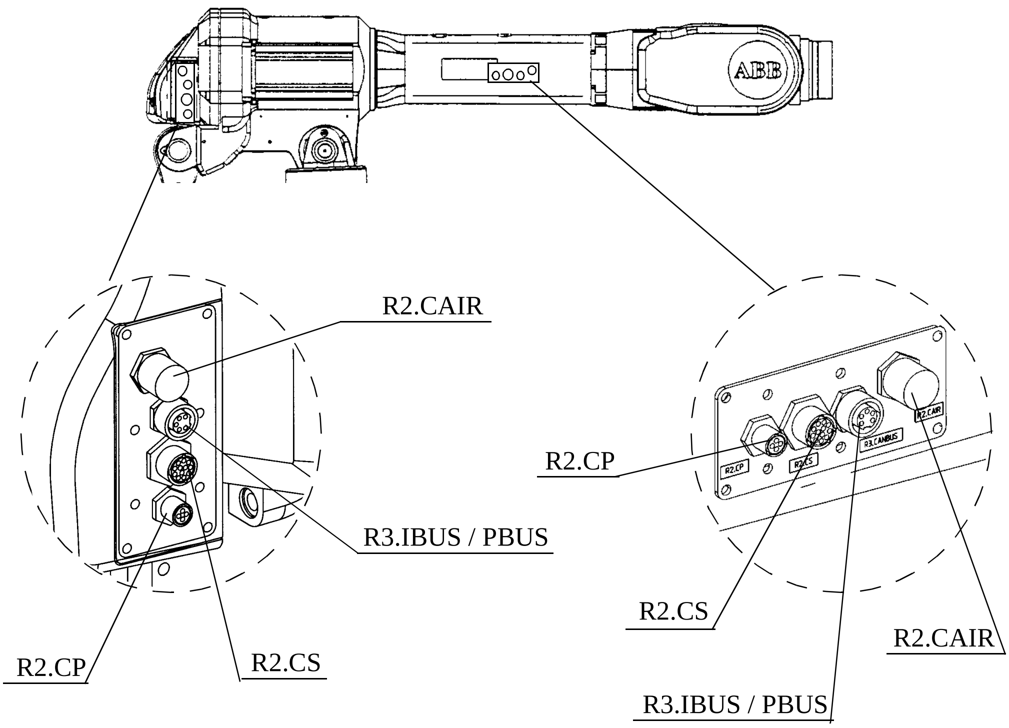


Figure 32 Location of customer connections on upper arm / arm housing.

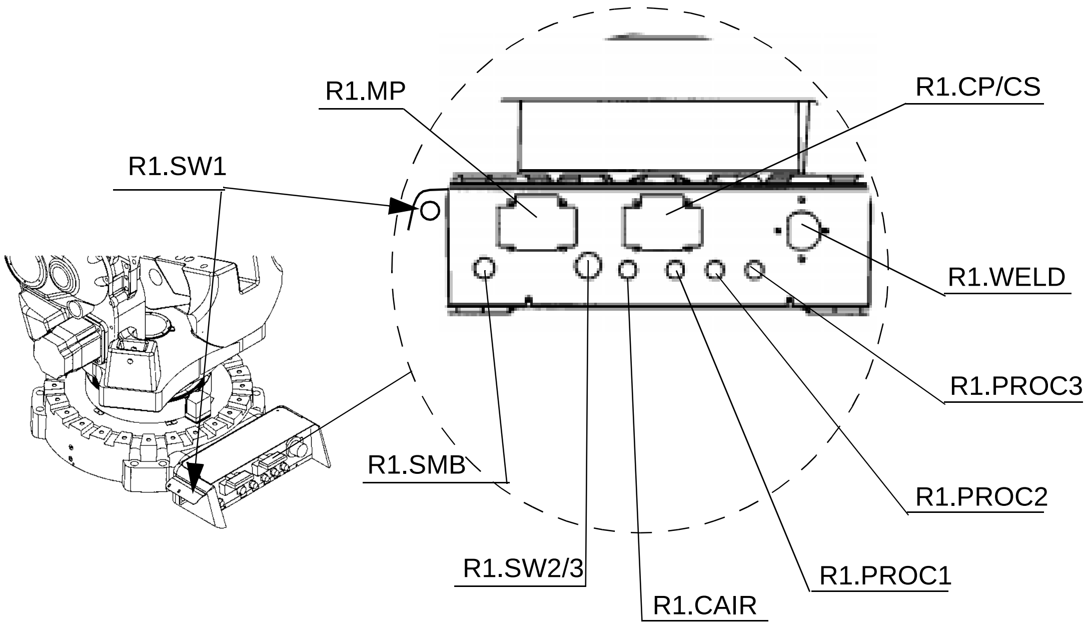


Figure 33 Location of customer connections on base

To connect to the power and signal cables from the connection unit to the manipulator base and on the upper arm, the following parts are recommended:

Connector R1.CP/CS. Signals on manipulator base. (Regarding **Item No.** see Figure 34). Included in delivery.				
Item	**Name**	**ABB art. no.**	**Type**	**Comments**
1	Adapter Plate	3HAC 5118-2	DIN 43 652	AMP
2	Hood	3HAC 5834-1	DIN 43 652	AMP/Harting (PG 29)
3	Compression gland	3HAC 5680-1		Hellerman (PG 29)
4	Socket housing D-Sub 3-pole.	3HAC 5119-3	DIN 43 652	
5	Socket housing D-Sub 9-pole.	3HAC 5119-7	DIN 43 652	
6	Socket housing D-Sub 25-pole.	3HAC 5119-9	DIN 43 652	

Connector R2.CS Signal and on the upper arm. (Regarding **Item No.** see Figure 35)				
Item	**Name**	**ABB art. no.**	**Type**	**Comments**
1	Socket con. 12p	3HAB 7290-12	UT 0714 12 SHT	Burndy
3	Socket	See Pin and Socket table below		
4	Pin con. 12p	3HAA 2602-2 5217 649-7	UT 061412 P04T UTG 61412 PN	Burndy EMC Burndy
5	Pin	See Pin and Socket table below		
6	Adaptor	3HAA 2601-2 5217 1038-3	UTG 14 ADT UTG 14 AD	Burndy EMC Burndy
7	Cable clamp	5217 649-8	UTG 14 PG	Burndy

Connector R3.CP Power signals on the upper arm. (Regarding **Item No.** see Figure 35)				
Item	**Name**	**ABB art. no.**	**Type**	**Comments**
1	Socket con. 8p	3HAB 7290-4	UT 07104 SHT	Burndy
3	Socket	See Pin and Socket table below		
4	Pin con. 4p	5217 649-43	UT 06104 P04T UTG 6104 PN	Burndy EMC Burndy
5	Pin	See Pin and Socket table below		
6	Adaptor	5217 649-44	UTG 10 ADT UTG 10 AD	Burndy EMC Burndy
7	Cable clamp	5217 649-78	UTG 10 PG	Burndy

Name	**ABB part no.**	**Type**	**Comments**
Pin	5217 649-72 5217 649-25 5217 649-70 5217 649-3 5217 649-68 5217 649-10 5217 649-31	24/26 24/26 20/22 20/22 16/20 24/26 16/20	Burndy Machine tooling Burndy Hand tooling Burndy Machine tooling Burndy Hand tooling Burndy Machine tooling Burndy Ground Burndy Ground
Socket	5217 649-73 5217 649-26 5217 649-71 5217 649-69 5217 1021-4 5217 1021-5	24/26 24/26 20/22 16/18 DIN 43 652 DIN 43 652	Burndy Machine tooling Burndy Hand tooling Burndy Machine tooling Burndy Machine tooling Tin bronze (CuSu) 0.14 - 0.5mm^2 AWG 20-26 Tin bronze (CuSu) 0.5 - 1.5mm^2 AWG 16-20

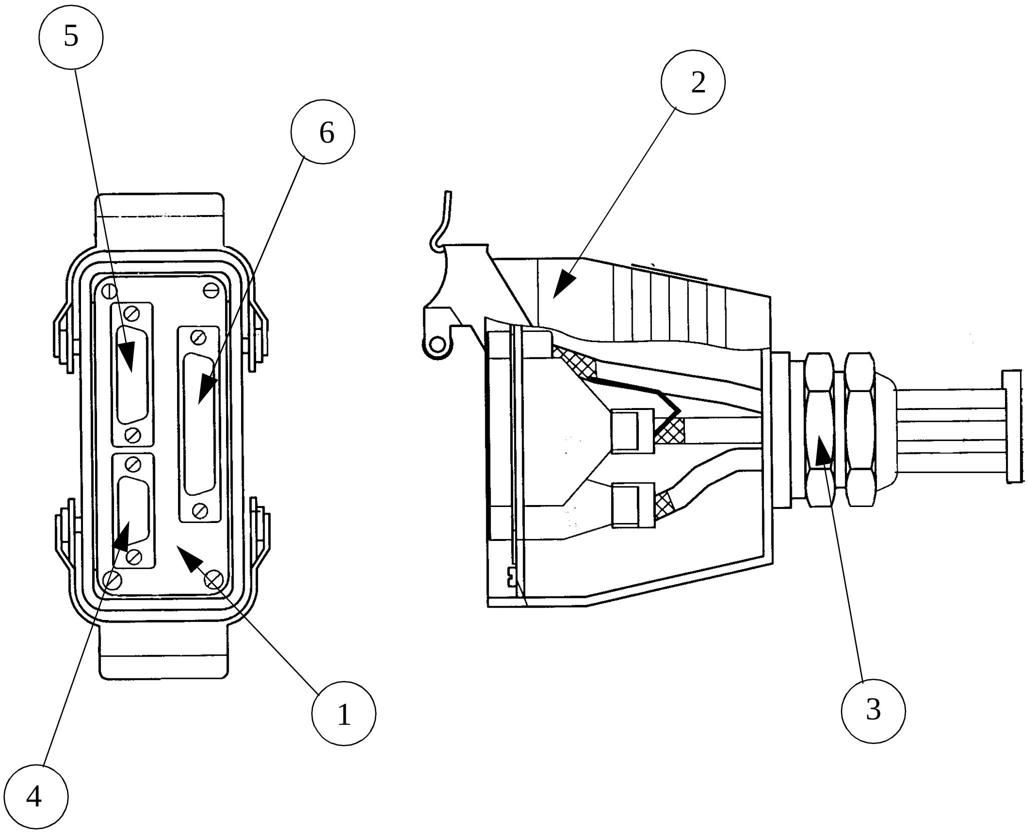


Figure 34 Customer connector

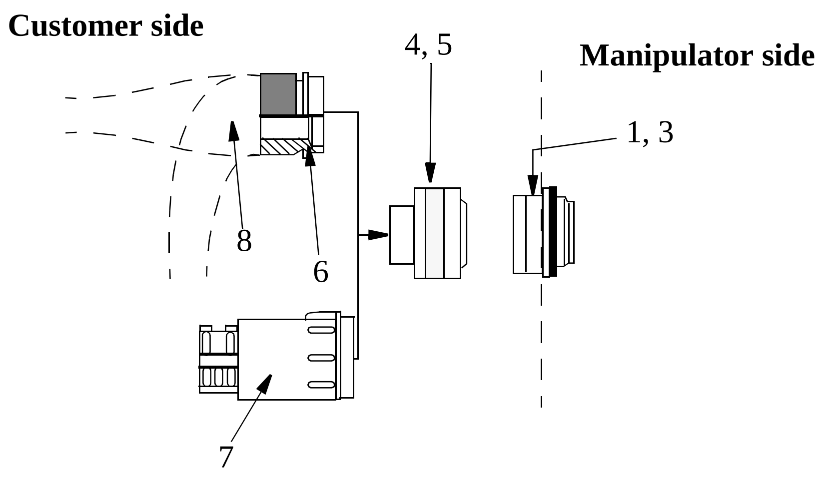


Figure 35 Burndy connector

3.7 Connection to screw terminal

Sockets with screwed connections for customer I/O, external safety circuits, customer sockets on the robot, external supply to electronics.

Signal identification	Location	Terminals
Safeguarded stop	Panel unit	X1 - X4
Digital I/O	I/O unit	X1 - X4
Combi I/O	I/O unit	X1 - X4, X6
Relay I/O	I/O unit	X1 - X4
RIO I/O	I/O unit	X1, X2
SIO 1, SIO 2	Backplane	X1, X2
CAN1 (internal unit)	Panel unit	X9
CAN 2 (manipulator, I/O units)	Backplane	X16
CAN 3 (external I/O units)	Backplane	X10
24 V supply (2 A fuse)		XT31
115/230 V AC supply		XT21

Location of socket terminals are shown below. See also circuit diagram, “View of control cabinet”, for more details.

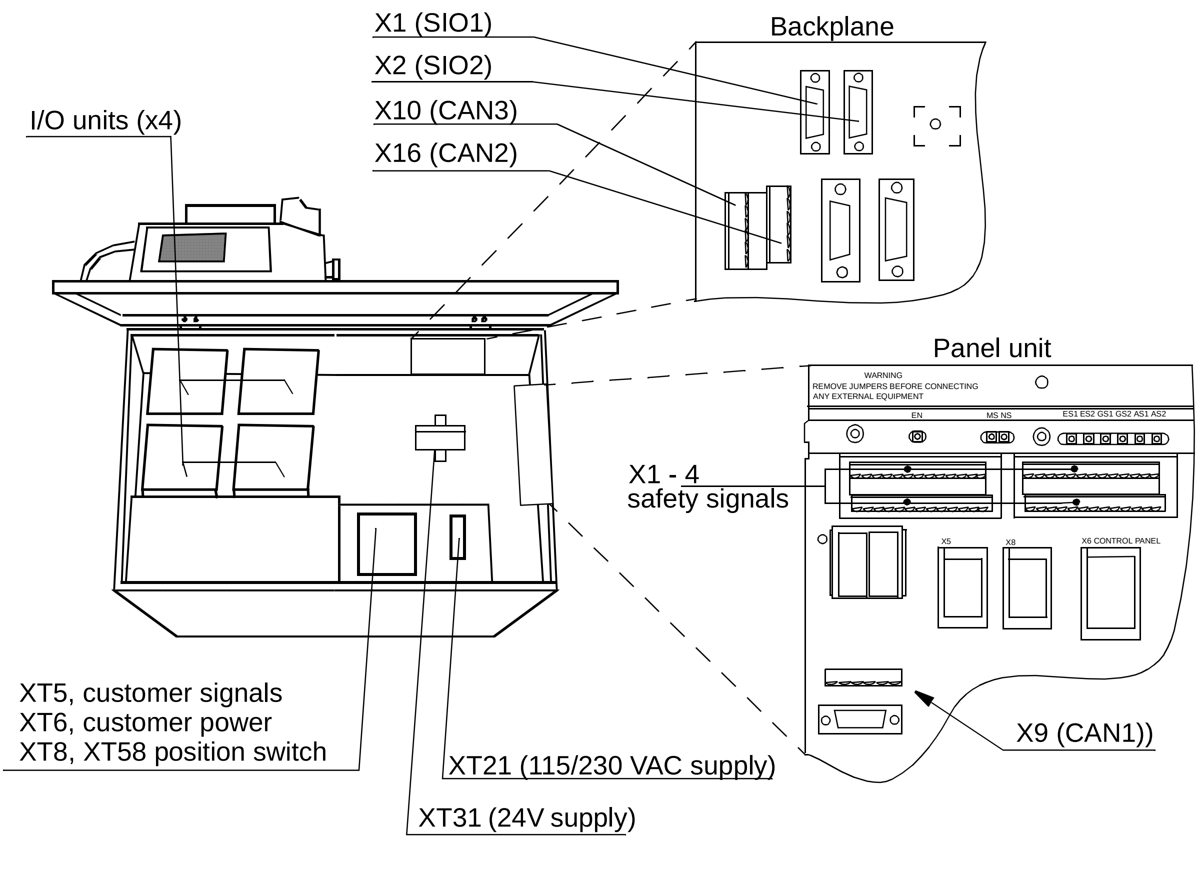


Figure 36 Screw terminal locations.

3.8 The MOTORS ON / MOTORS OFF circuit

To set the robot to MOTORS ON mode, two identical chains of switches must be closed. If any switch is open, the robot will switch to MOTORS OFF mode. As long as the two chains are not identical, the robot will remain in MOTORS OFF mode.
Figure 37 shows an outline principal diagram of the available customer connections, AS, GS and ES.

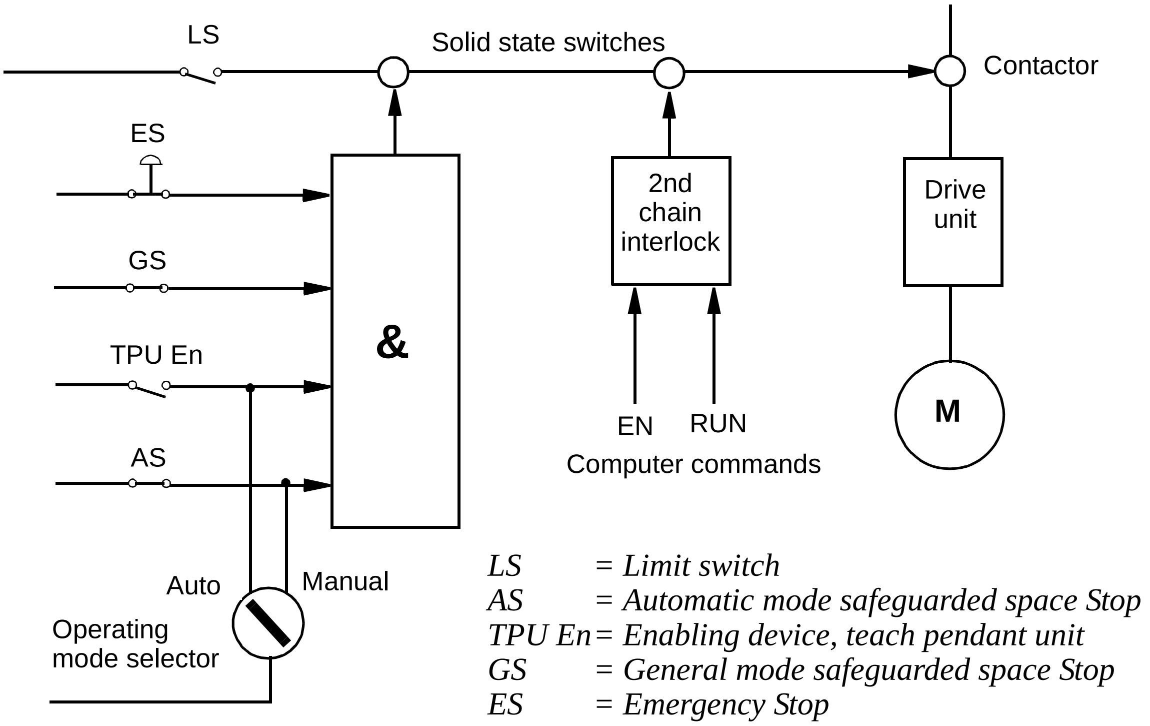
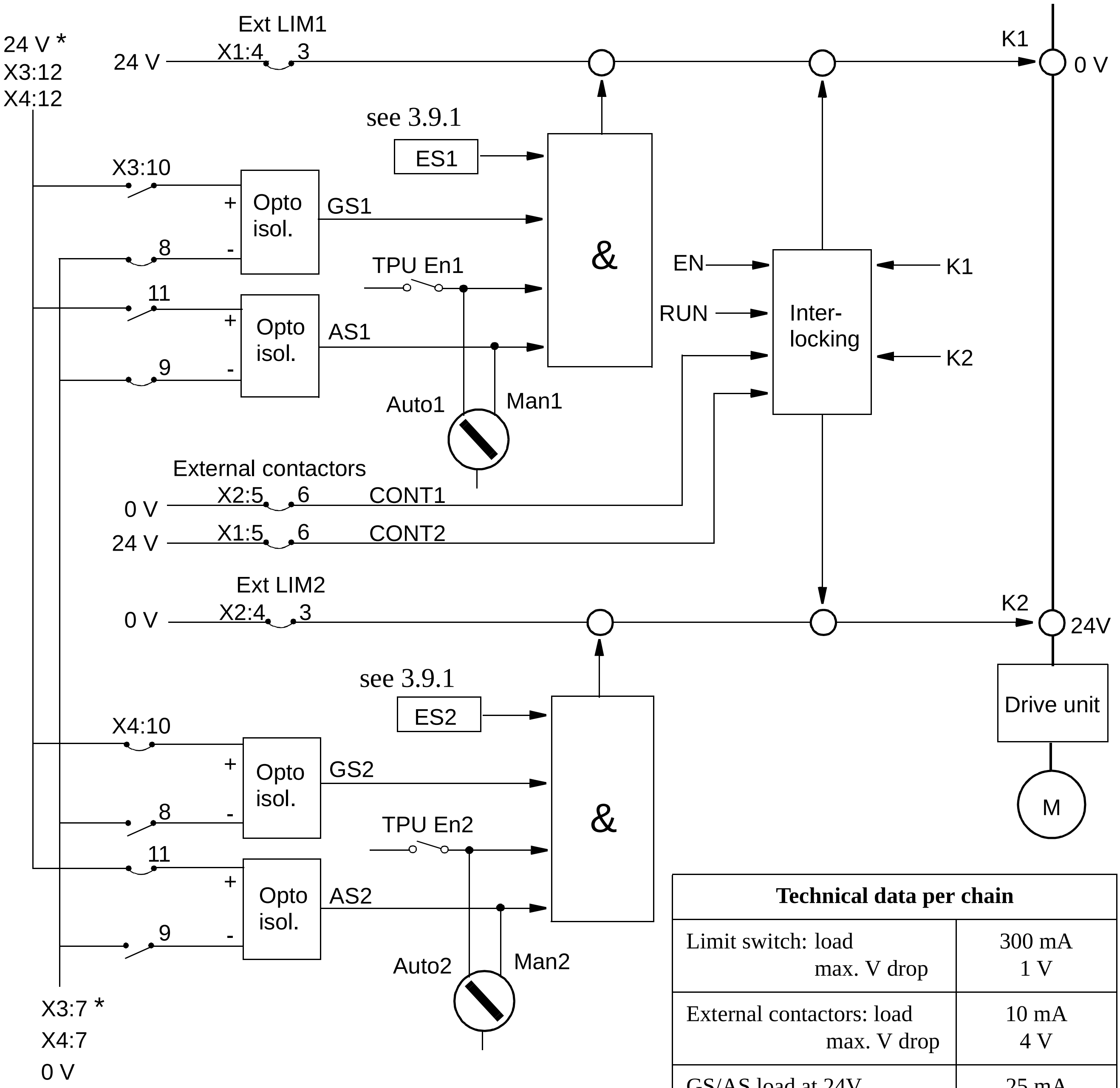


Figure 37 MOTORS ON /MOTORS OFF circuit.

3.9 Connection of safety chains



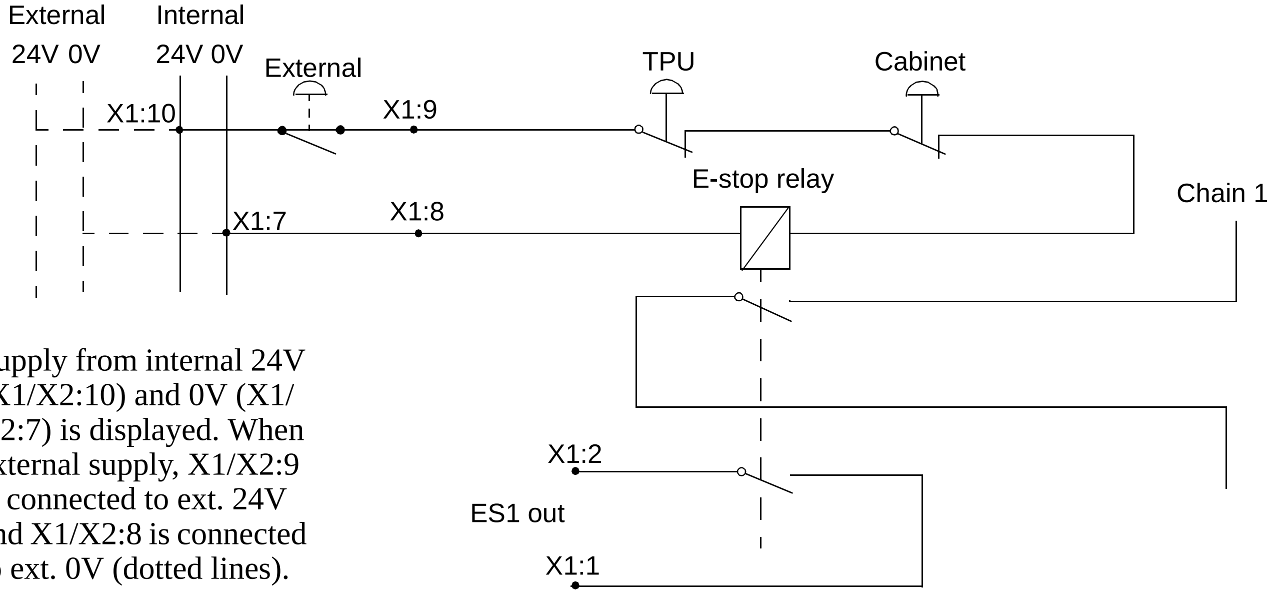
*)
Supply from internal 24V (X3/X4:12) and 0 V (X3/X4:7) is displayed.
When external supply of GS and AS, X3/X4:10,11 is connected to 24 V and X3/X4:8,9 is connected to external 0 V

X1-X4 connection tables, see section 3.10.

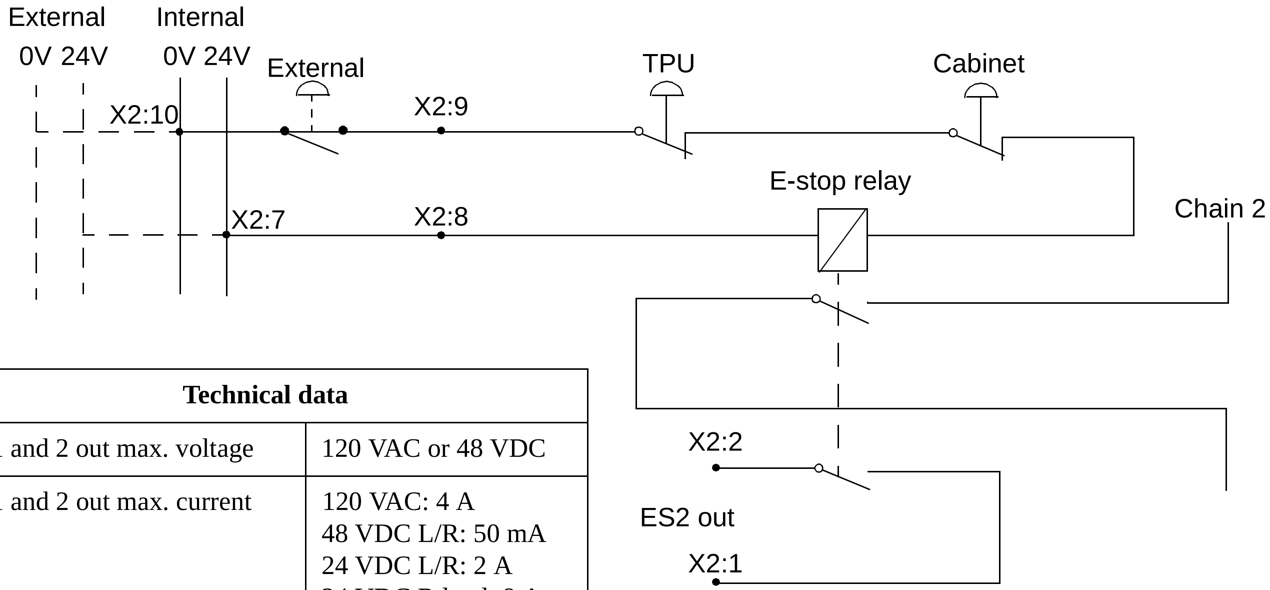
Technical data per chain	
Limit switch: load max. V drop	300 mA 1 V
External contactors: load max. V drop	10 mA 4 V
GS/AS load at 24V	25 mA
GS/AS closed “1”	> 18 V
GS/AS open “0”	< 5 V
External supply of GS/AS	max. +35VDC min. -35VDC
Max. potential relative to the cabinet earthing and other group of signals	300 V
Signal class	control signals

Figure 38 Diagram showing the two-channel safety chain.

3.9.1 Connection of ES1/ES2 on panel unit



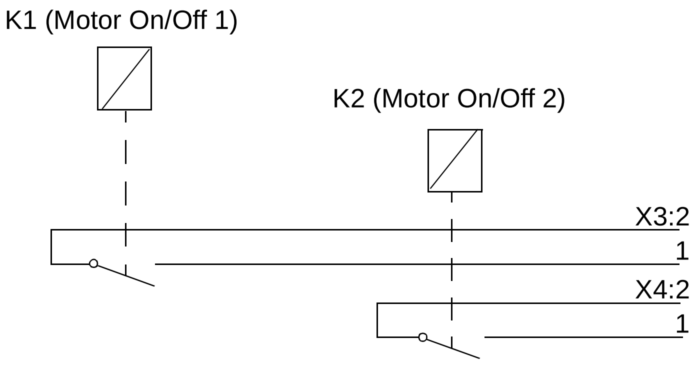
Supply from internal 24V (X1/X2:10) and 0V (X1/ X2:7) is displayed. When external supply, X1/X2:9 is connected to ext. 24V and X1/X2:8 is connected to ext. 0V (dotted lines).



Technical data	
ES1 and 2 out max. voltage	120 VAC or 48 VDC
ES1 and 2 out max. current	120 VAC: 4 A 48 VDC L/R: 50 mA 24 VDC L/R: 2 A 24 VDC R load: 8 A
External supply of ES relays =	min. 22 V between terminals X1:9,8 and X2:9,8 respectively
Rated current per chain	40 mA
Max. potential relative to the cabinet earthing and other groups of signals	300 V
Signal class	control signals

Figure 39 Terminals for emergency circuits.

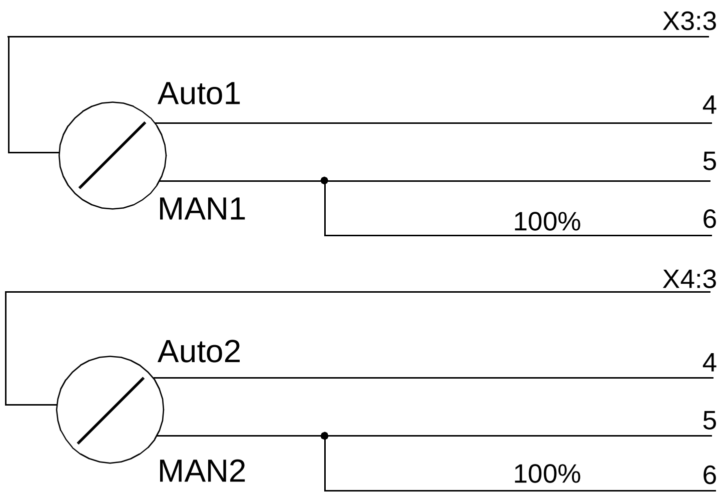
3.9.2 Connection to Motor On/Off contactors



Technical data	
Max. voltage	48V DC
Max. current	4A
Max. potential relative to the cabinet earthing and other groups of signals	300V
Signal class	control

Figure 40 Terminals for customer use.

3.9.3 Connection to operating mode selector



Technical data	
Max. voltage	48V DC
Max. current	4A
Max. potential relative to the cabinet earthing and other groups of signals	300V
Signal class	control

Figure 41 Terminals customer use.

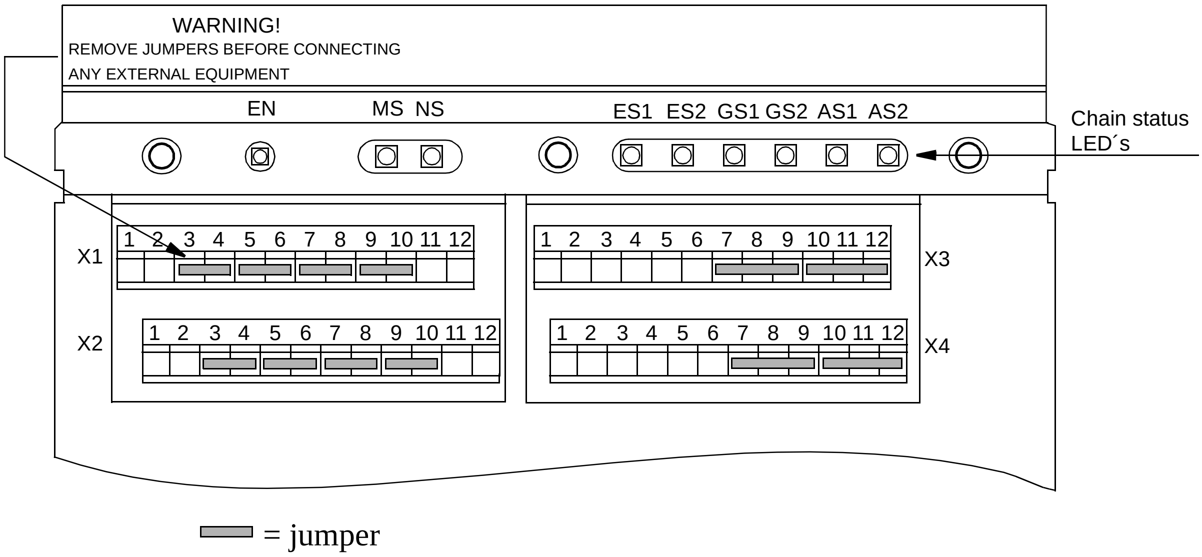
3.9.4 Connection to brake contactor

Technical data	
Max. voltage	48V DC
Max. current	4A
Max. potential relative to the cabinet earthing and other groups of signals	300V
Signal class	control

Figure 42 Terminal for customer use.

3.10 External customer connections

Customer contacts, on panel unit: X1- X4.



Customer connections: X1 - X4, located on the panel unit.
The signal names refer to the circuit diagram in chapter 11.

	X1	
Signal name	**Pin**	**Comment**
ES1 out:B	1	Emergency stop out chain 1
ES1 out:A	2	Emergency stop out chain 1
Ext. LIM1:B	3	External limit switch chain 1
Ext. LIM1:A	4	External limit switch chain 1
0V	5	0V external contactor 1
CONT1	6	External contactor 1
Int. 0V ES1	7	Internal supply 0V of emergency stop chain 1
Ext. 0V ES1	8	External supply 0V of emergency stop chain 1
Ext. ES1 IN	9	External emergency stop in chain 1
Ext. ES1 OUT	10	External emergency stop out chain 1
Ext. BRAKE B	11	Contactor for external brake
Ext. BRAKE A	12	Contactor for external brake

	X2	
Signal name	**Pin**	**Comment**
ES2 out:B	1	Emergency stop out chain 2
ES2 out:A	2	Emergency stop out chain 2
Ext. LIM2:B	3	External limit switch chain 2
Ext. LIM2:A	4	External limit switch chain 2
24V panel	5	24V external contactor 2
CONT2	6	External contactor 2
Int. 24V ES2	7	Internal supply 24V of emergency stop chain 2
Ext. 24V ES2	8	External supply 24V of emergency stop chain 2
Ext. ES2 IN	9	External emergency stop in chain 2
Ext. ES2 OUT	10	External emergency stop out chain 2
	11	Not used
	12	Not used

	X3	
Signal name	**Pin**	**Comment**
Ext. MON 1:B	1	Motor contactor 1
Ext. MON 1:A	2	Motor contactor 1
Ext. com 1	3	Common 1
Ext. auto 1	4	Auto 1
Ext. man 1	5	Manual 1
Ext. man FS 1	6	Manual full speed 1
0V	7	0V to auto stop and general stop
GS1-	8	General stop minus chain 1
AS1-	9	Auto stop minus chain 1
GS1+	10	General stop plus chain 1
AS1+	11	Auto stop plus chain 1
24V panel	12	24V to auto stop and general stop

	X4	
Signal name	**Pin**	**Comment**
Ext. MON 2:B	1	Motor contactor 2
Ext. MON 2:A	2	Motor contactor 2
Ext. com 2	3	Common 2
Ext. auto 2	4	Auto 2
Ext. man 2	5	Manual 2
Ext. man FS 2	6	Manual full speed 2
0V	7	0V to auto stop and general stop
GS2-	8	General stop minus chain 2
AS2-	9	Auto stop minus chain 2
GS2+	10	General stop plus chain 2
AS2+	11	Auto stop plus chain 2
24V panel	12	24V to auto stop and general stop

3.11 External safety relay

The Motor On/Off mode in the controller can operate with external equipment if external relays are used. Two examples are shown below.

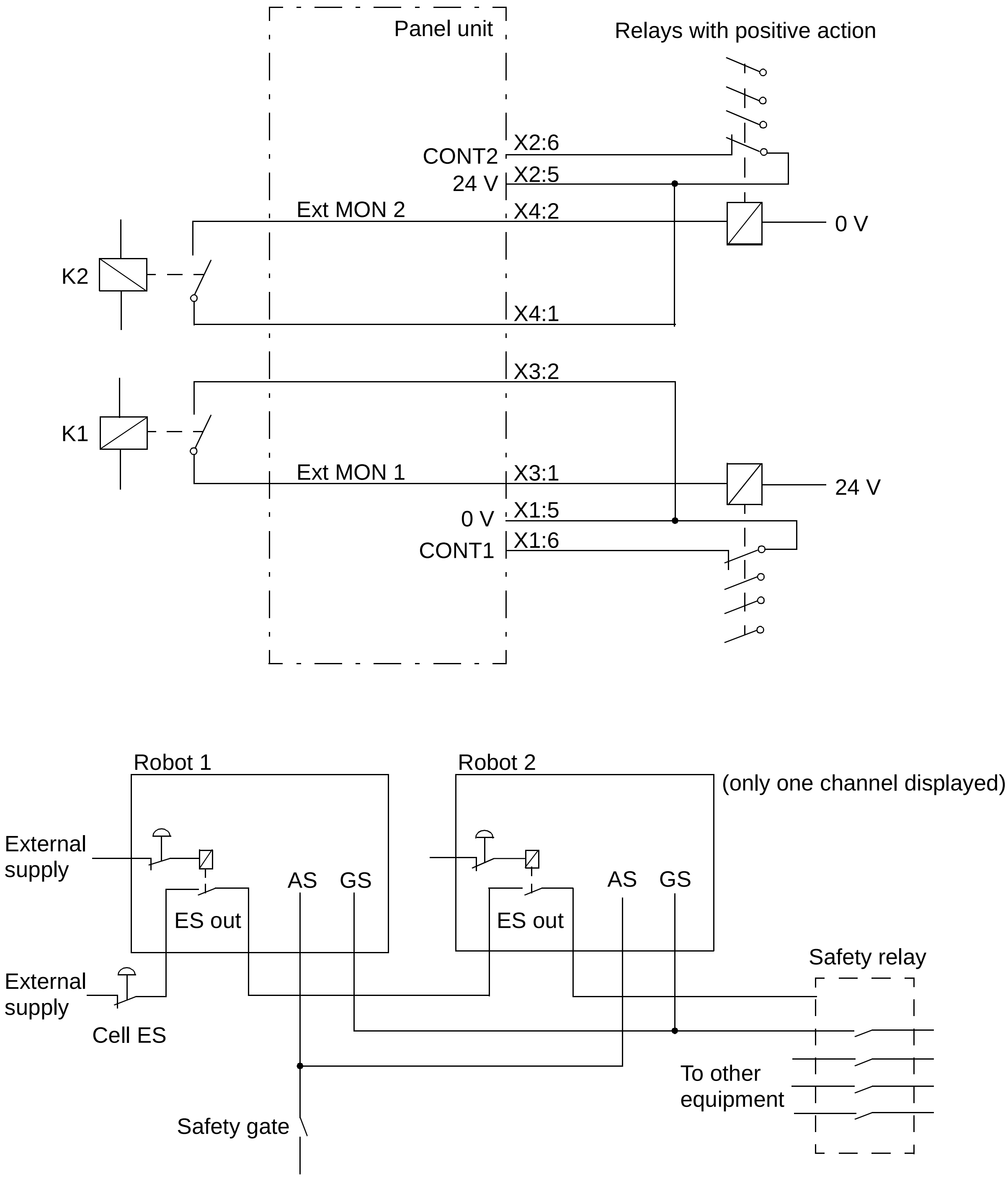


Figure 43 Diagram for using external safety relays.

3.12 Safeguarded space stop signals

According to the safety standard ISO/DIS 11161 "Industrial automation systems - safety of integrated manufacturing systems - Basic requirements", there are two categories of safety stops, category 0 and category 1, see below:

The category 0 stop is to be used when, for safety analysis purposes, the power supply to the motors must be switched off immediately, such as when a light curtain, used to protect against entry into the work cell, is passed. This uncontrolled motion stop may require special restart routines if the programmed path changes as a result of the stop.

Category 1 is to be preferred, if accepted for safety analysis purposes, such as when gates are used to protect against entry into the work cell. This controlled motion stop takes place within the programmed path, which makes restarting easier.

3.12.1 Delayed safeguarded space stop

All the robot's safety stops are as default category 0 stops.
Safety stops of category 1 can be obtained by activating the delayed safeguarded space stop together with AS or GS. A delayed stop gives a smooth stop. The robot stops in the same way as a normal program stop with no deviation from the programmed path. After approx. 1 second the power supply to the motors is shut off. The function is activated by setting a parameter, see User's Guide, section System Parameters, Topic: Controller.

Note! To ensure MOTORS OFF status, the activating switch must be kept open for more than one second. If the switch is closed within the delay, the robot stops and will remain in MOTORS ON mode.

3.13 Available voltage

3.13.1 24 V I/O supply

The robot has a 24 V supply available for external and internal use.

This voltage is used in the robot for supplying the drive unit fans and the manipulator brakes.
The 24 V I/O is not galvanically separated from the rest of the controller voltages.

Technical data

Voltage	24.0 - 26.4 V
Ripple	Max. 0.2 V
Permitted customer load	Max. 6 A (7.5 A if DSQC 374)
Current limit	Max. 18 A (12 A if DSQC 374)
Short-circuit current	Max. 13 A (average value)(~ 0 A if DSQC 374)

24 V I/O available for customer connections at:

XT.31.2	24 V (via 2 A fuse)
XT.31.1	for own fuses, max. fuse size is 2 A to ensure breaking at short circuit Note! DSQC 374 can not trip any fuses.
XT.31.4	0 V (connected to cabinet structure)

3.13.2 115/230 V AC supply

The robot has a AC supply available for external and internal use.

This voltage is used in the robot for supplying optional service outlets.

The AC supply is not galvanically separated from the rest of the controller voltages.

Technical data

Voltage	115 or 230 V
Permitted customer load	Max. 500 VA
Fuse size	3.15 A (230 V), 6.3 A (115 V)

AC supply is available for customer connections at:

XT.21.1-5	230 V (3.15 A)
XT.21.6-8	115 V (6.3 A)
XT.21.9-13	N (connected to cabinet structure)

3.14 External 24 V supply

An external supply must be used in the following cases:

- When the internal supply is insufficient
- When the emergency stop circuits must be independent of whether or not the robot has power on, for example.
- When there is a risk that major interference can be carried over into the internal 24 V supply

An external supply is recommended to make use of the advantages offered by the galvanic insulation on the I/O units or on the panel unit.

The neutral wire in the external supply must be connected in such a way as to prevent the maximum permitted potential difference in the chassis earth being exceeded. For example, a neutral wire can be connected to the chassis earth of the controller, or some other common earthing point.

Technical data:

Potential difference to chassis earth:		Max. 60 V continuous Max. 500 V for 1 minute
Permitted supply voltage:	I/O units	19 - 35 V including ripple
	panel unit	20.6 - 30 V including ripple

3.15 Connection of extra equipment to the manipulator

Technical data for customer connections

Customer Power CP

Conductor area	1.0 mm^2
Max. voltage	250 V AC
Max. current	8 A

Customer Signals CS

Conductor area	0.241 mm^2
Max. voltage	50 V AC / DC
Max. current	250 mA

With CANBUS

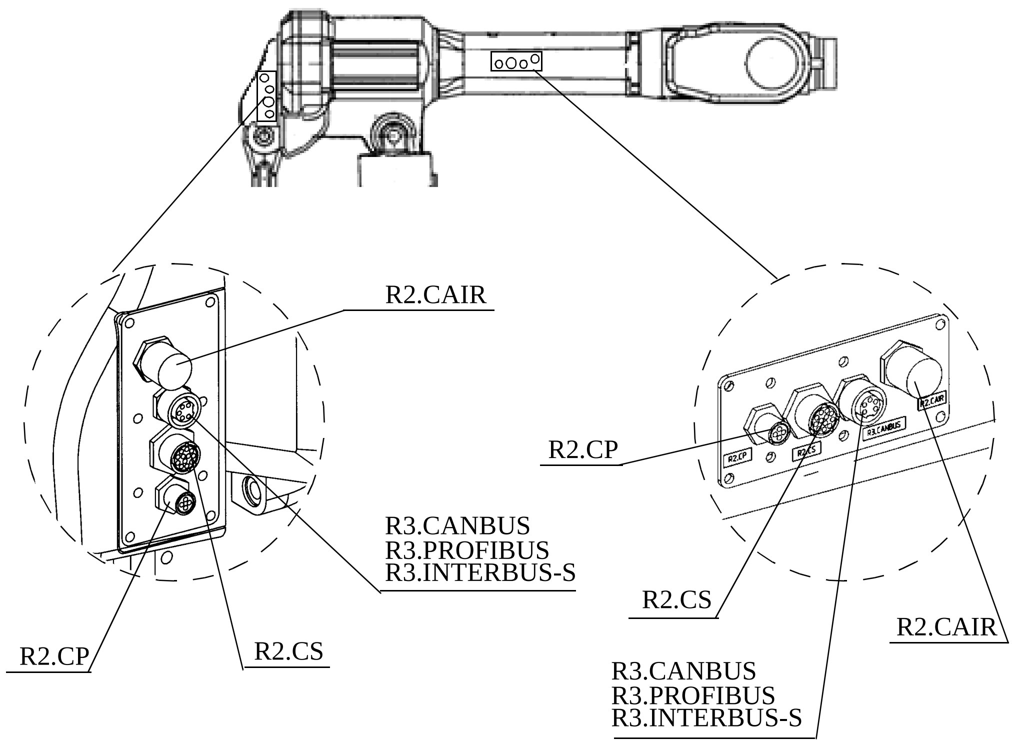


Figure 44 Location of customer connections on upper arm / arm housing.

With CANBUS

Signal name	Customer terminal controller, see Figure 36	Customer connector on manipulator base, R1 (cable not supplied)		Customer connector on upper arm/ arm housing, R3
Power supply				
CPF	XT6.1	R1.CP/CS.1	(3p D-Sub)	R2.CP.A
CPJ	XT6.2	R1.CP/CS.2	(3p D-Sub)	R2.CP.B
PE	XT6.3	R1.CP/CS.3	(3p D-Sub)	R2.CP.C
Signals				
CSA	XT5.1	R1.CP/CS.1	(25p D-Sub)	R3.CS.A
CSB	XT5.2	R1.CP/CS.2	(25p D-Sub)	R3.CS.B
CSC	XT5.3	R1.CP/CS.3	(25p D-Sub)	R3.CS.C
CSD	XT5.3	R1.CP/CS.4	(25p D-Sub)	R3.CS.D
CSE	XT5.5	R1.CP/CS.5	(25p D-Sub)	R3.CS.E
CSF	XT5.6	R1.CP/CS.6	(25p D-Sub)	R3.CS.F
CSG	XT5.7	R1.CP/CS.7	(25p D-Sub)	R3.CS.G
CSH	XT5.8	R1.CP/CS.8	(25p D-Sub)	R3.CS.H
CSJ	XT5.9	R1.CP/CS.9	(25p D-Sub)	R3.CS.J
CSK	XT5.10	R1.CP/CS.10	(25p D-Sub)	R3.CS.K
CanBus				
DRAIN				R3.CANBUS.1
+24VCAN		R1.CP/CS.1	(9pD-Sub)	R3.CANBUS.2
0VCAN		R1.CP/CS.2	(9pD-Sub)	R3.CANBUS.3
CAN_H		R1.CP/CS.5	(9pD-Sub)	R3.CANBUS.4
CAN_L		R1.CP/CS.9	(9pD-Sub)	R3.CANBUS.5

With INTERBUS-S

Signal name	Customer terminal controller, see Figure 36	Customer connector on manipulator base, R1 (cable not supplied)		Customer connector on upper arm/ arm housing, R3
Power supply				
CPF	XT6.1	R1.CP/CS.1	(3p D-Sub)	R2.CP.A
CPJ	XT6.2	R1.CP/CS.2	(3p D-Sub)	R2.CP.B
PE	XT6.3	R1.CP/CS.3	(3p D-Sub)	R2.CP.C
Signals				
CSA	XT5.1	R1.CP/CS.1	(25p D-Sub)	R3.CS.A
CSB	XT5.2	R1.CP/CS.2	(25p D-Sub)	R3.CS.B
CSC	XT5.3	R1.CP/CS.3	(25p D-Sub)	R3.CS.C
CSD	XT5.3	R1.CP/CS.4	(25p D-Sub)	R3.CS.D
CSE	XT5.5	R1.CP/CS.5	(25p D-Sub)	R3.CS.E
CSF	XT5.6	R1.CP/CS.6	(25p D-Sub)	R3.CS.F
CSG	XT5.7	R1.CP/CS.7	(25p D-Sub)	R3.CS.G
CSH	XT5.8	R1.CP/CS.8	(25p D-Sub)	R3.CS.H
CSJ	XT5.9	R1.CP/CS.9	(25p D-Sub)	R3.CS.J
CSK	XT5.10	R1.CP/CS.10	(25p D-Sub)	R3.CS.K
InterBus-S				
DRAIN				R3.IBUS/PBUS.1
+24VCAN		R1.CP/CS.1	(9pD-Sub)	R3.IBUS/PBUS.2
0VCAN		R1.CP/CS.2	(9pD-Sub)	R3.IBUS/PBUS.3
CAN_H		R1.CP/CS.5	(9pD-Sub)	R3.IBUS/PBUS.4
COM		R1.CP/CS.9	(9pD-Sub)	R3.IBUS/PBUS.5
SHIELD		R1.CP/CS.9	(9pD-Sub)	R3.IBUS/PBUS.8

With PROFIBUS

Signal name	**Customer terminal controller, see Figure 36**	**Customer connector on manipulator base, R1** (cable not supplied)		**Customer connector on upper arm/ arm housing, R3**
Power supply				
CPF	XT6.1	R1.CP/CS.1	(3p D-Sub)	R2.CP.A
CPJ	XT6.2	R1.CP/CS.2	(3p D-Sub)	R2.CP.B
PE	XT6.3	R1.CP/CS.3	(3p D-Sub)	R2.CP.C
Signals				
CSA	XT5.1	R1.CP/CS.1	(25p D-Sub)	R3.CS.A
CSB	XT5.2	R1.CP/CS.2	(25p D-Sub)	R3.CS.B
CSC	XT5.3	R1.CP/CS.3	(25p D-Sub)	R3.CS.C
CSD	XT5.3	R1.CP/CS.4	(25p D-Sub)	R3.CS.D
CSE	XT5.5	R1.CP/CS.5	(25p D-Sub)	R3.CS.E
CSF	XT5.6	R1.CP/CS.6	(25p D-Sub)	R3.CS.F
CSG	XT5.7	R1.CP/CS.7	(25p D-Sub)	R3.CS.G
CSH	XT5.8	R1.CP/CS.8	(25p D-Sub)	R3.CS.H
CSJ	XT5.9	R1.CP/CS.9	(25p D-Sub)	R3.CS.J
CSK	XT5.10	R1.CP/CS.10	(25p D-Sub)	R3.CS.K
Profibus				
RxD / TxD-P				R3.IBUS/PBUS.1
RxD / TxD-P		R1.CP/CS.1	(9pD-Sub)	R3.IBUS/PBUS.2
VP		R1.CP/CS.2	(9pD-Sub)	R3.IBUS/PBUS.6
DGND		R1.CP/CS.5	(9pD-Sub)	R3.IBUS/PBUS.7
SHIELD		R1.CP/CS.9	(9pD-Sub)	R3.IBUS/PBUS.8

3.15.1 Connection of signal lamp on upper arm (option)

Connections for the signal lamp are located under the cover for motor axis 4.

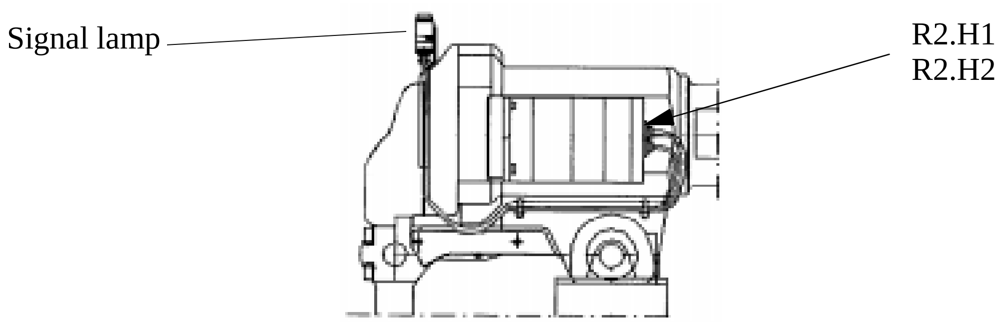


Figure 45 Location of signal lamp.

3.16 Distributed I/O units

3.16.1 General

Up to 20* units can be connected to the same controller but only four of these can be installed inside the controller. Normally a distributed I/O unit is placed outside the controller. The maximum total length of the distributed I/O cable is 100 m (from one end of the chain to the other end). The controller can be one of the end points or be placed somewhere in the middle of the chain. For setup parameters, see User's Guide, section System Parameters, Topic: I/O Signals.

*) some ProcessWare reduces the number due to use of SIM boards.

3.16.2 Sensors

Sensors are connected to one optional digital unit.

Technical data

See Product Specification IRB 6400, chapter 3.10.

The following sensors can be connected:

Sensor type	**Signal level**	
Digital one bit sensors	High	“1”
	Low	“0”
Digital two bit sensors	High	“01”
	No signal	“00”
	Low	“10”
	Error status	“11” (stop program running)

3.16.3 Connection and address keying of the CAN-bus

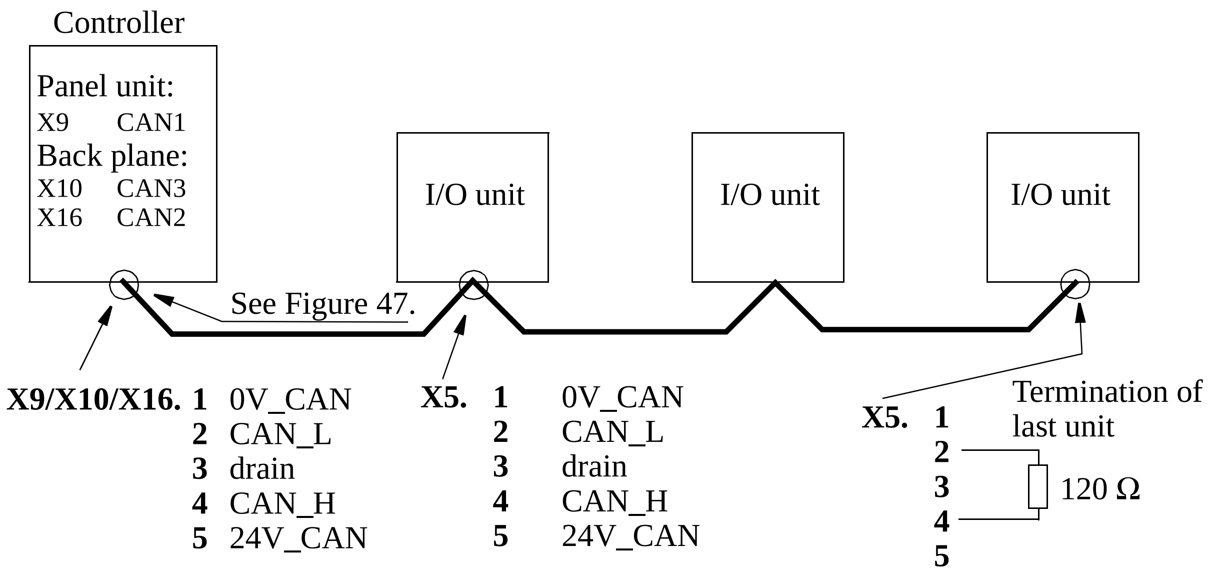


Figure 46 Example of connection of the CAN-bus

1. When the I/O unit is fitted inside the control cabinet (this is standard when choosing the options on the Specification form), its CAN bus is connected to CAN1, X9 on the panel unit (see 3.7). No termination is required when only CAN1 is used.

2. When the I/O unit is fitted outside the control cabinet, its CAN bus must be connected to CAN3, X10 on the backplane of the control cabinet.

3. When the I/O unit is fitted on the manipulator, its CAN bus must be connected to CAN2, X16 on the backplane of the control cabinet.

NOTE!
When only one of the X10/X16 is connected, the other must be terminated with 120 Ω.

24V_CAN must not be used to supply digital inputs and outputs. Instead, they must be supplied either by the 24 V I/O from the cabinet or externally by a power supply unit.

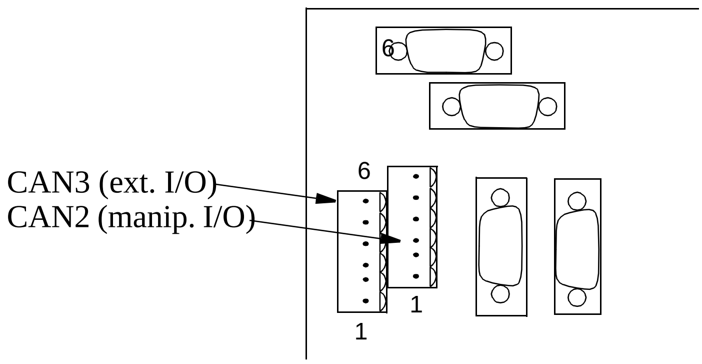
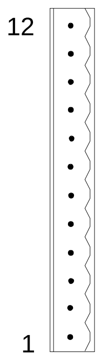


Figure 47 CAN connections on back plane.

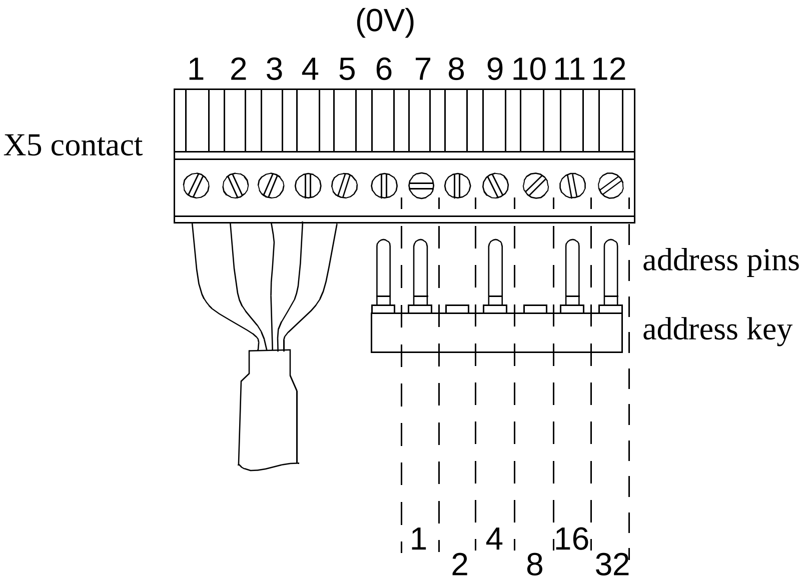
DeviceNet Connector

		X5	
Input and ID	**Signal name**	**Pin**	**Description**
	V- 0V	1	Supply voltage GND
	CAN_L	2	CAN signal low
	DRAIN	3	Shield
	CAN_H	4	CAN signal high
	V+	5	Supply voltage 24VDC
	GND	6	Logic GND
	MAC ID 0	7	Board ID bit 0 (LSB)
	MAC ID 1	8	Board ID bit 1
	MAC ID 2	9	Board ID bit 2
	MAC ID 3	10	Board ID bit 3
	MAC ID 4	11	Board ID bit 4
	MAC ID 5	12	Board ID bit 5 (MSB)

ID setting

Each I/O unit is given a unique address (ID). The connector contains address pins and can be keyed as shown in Figure 48.

When all terminals are unconnected the highest address is obtained, i.e. 63. When all are connected to 0 V, the address is 0 (which will cause an error since address 0 is used by the Panel unit). To avoid interference with other internal addresses, do not use addresses 0-9.



Example:

To obtain address 10:
cut off address pins 2 and 8, see figure.

To obtain address 25:
cut off address pins 1, 8 and 16.

Figure 48 Examples of address keying.

3.16.4 Digital I/O DSQC 328 (optional)

The digital I/O unit has 16 inputs and outputs, divided up into groups of eight. All groups are galvanically isolated and may be supplied from the cabinet 24 V I/O supply or from a separate supply.

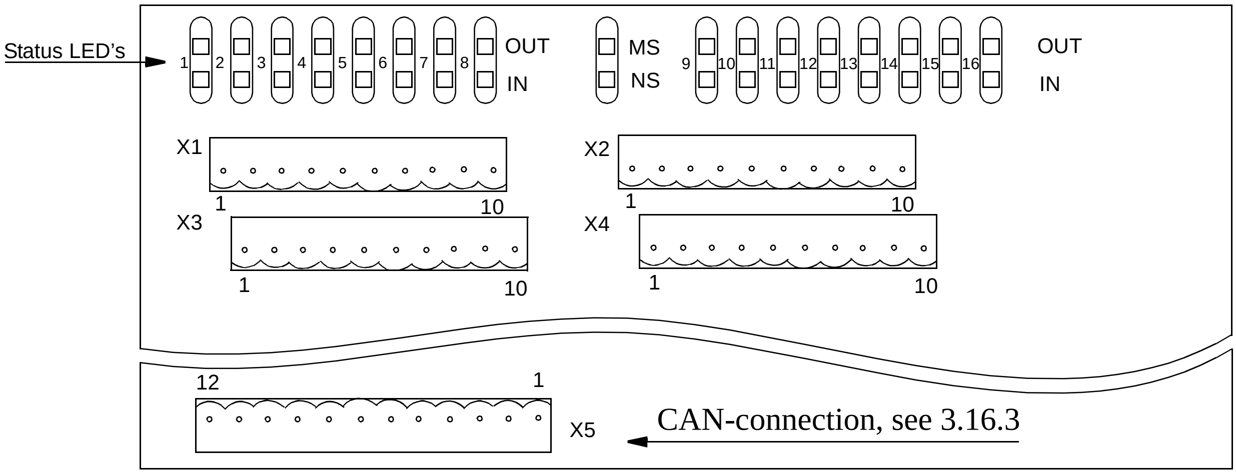
Technical data

See Product Specification IRB 6400, chapter 3.10.

Further information

For setup parameters, see User’s Guide, section System Parameters, Topic: Controller. Circuit diagram, see chapter 11.

CONNECTION TABLE
Customer contacts: X1 - X4



Unit function	Signal name	X1 Pin	Customer conn.	Signal name	X2 Pin
Opto. isol.	Out ch 1	1		Out ch 9	1
	Out ch 2	2		Out ch 10	2
	Out ch 3	3		Out ch 11	3
	Out ch 4	4		Out ch 12	4
	Out ch 5	5		Out ch 13	5
	Out ch 6	6		Out ch 14	6
	Out ch 7	7		Out ch 15	7
	Out ch 8	8		Out ch 16	8
	0V for out 1-8	9	0V	0V for out 9-16	9
	24V for out 1-8	10*	24V	24V for out 9-16	10*

***)**
If supervision of the supply voltage is required, a bridge connection can be made to an optional digital input. The supervision instruction must be written in the RAPID program.

Unit function	Signal name	X3 Pin	Customer conn.	Signal name	X4 Pin
Opto. isol.	In ch 1	1	24 V	In ch 9	1
	In ch 2	2		In ch 10	2
	In ch 3	3		In ch 11	3
	In ch 4	4		In ch 12	4
	In ch 5	5		In ch 13	5
	In ch 6	6		In ch 14	6
	In ch 7	7		In ch 15	7
	In ch 8	8		In ch 16	8
	0V for in 1-8	9	0 V	0V for in 9-16	9
	Not used	10		Not used	10

NOTE!
The input current is 5.5 mA (at 24V) on the digital inputs. A capacitor connected to ground, to prevent disturbances, causes a short rush of current when setting the input. When connecting outputs, sensitive to pre-oscillation current, a serial resistor (100 Ω) may be used.

3.16.5 AD Combi I/O DSQC 327 (optional)

The combi I/O unit has 16 digital inputs divided into groups of 8, and 16 digital outputs divided into two groups of 8. All groups are galvanically isolated and may be supplied from the cabinet 24 V I/O supply or from a separate supply.

The two analog outputs belong to a common group which is galvanically isolated from the electronics of the controller. The supply to the two analog outputs is generated from 24 V_CAN (with galvanically isolated DC/AC converter).

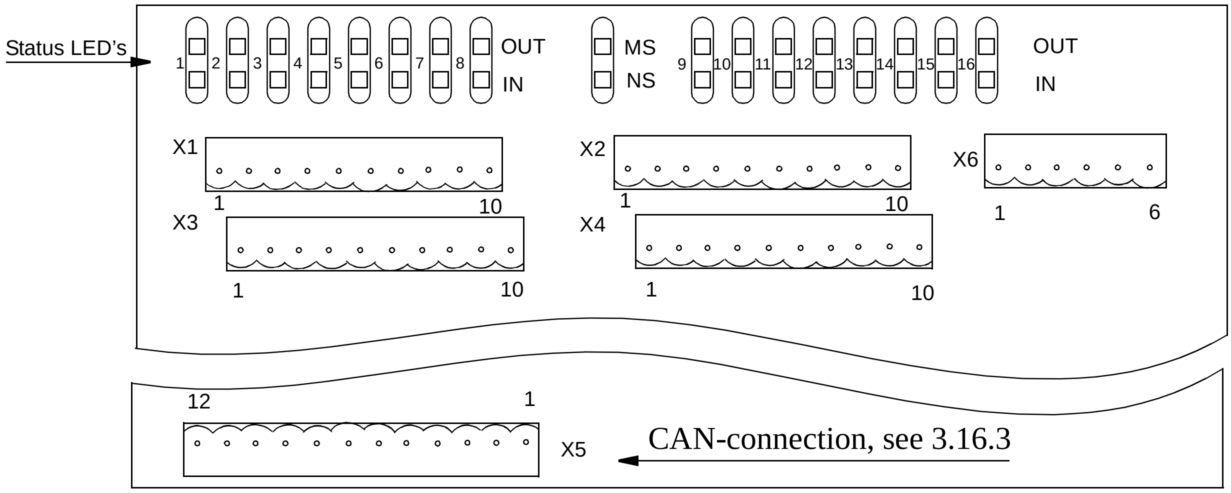
Technical data

See Product Specification IRB 6400, chapter 3.10.

Further information

For setup parameters, see User's Guide, section System Parameters, Topic: Controller. Circuit diagram, see chapter 11.

CONNECTION TABLE
Customer contacts: X1 - X4, X6



		X1			X2
Unit function	**Signal name**	**Pin**	**Customer conn.**	**Signal name**	**Pin**
Opto. isol.	Out ch 1	1		Out ch 9	1
	Out ch 2	2		Out ch 10	2
	Out ch 3	3		Out ch 11	3
	Out ch 4	4		Out ch 12	4
	Out ch 5	5		Out ch 13	5
	Out ch 6	6		Out ch 14	6
	Out ch 7	7		Out ch 15	7
	Out ch 8	8		Out ch 16	8
	0V for out 1-8	9	0V	0V for out 9-16	9
	24V for out 1-8	10*	24V	24V for out 9-16	10*

***)**
If supervision of the supply voltage is required, a bridge connection can be made to an optional digital input. The supervision instruction must be written in the RAPID program.

Unit function	Signal name	X3 Pin	Customer conn.	Signal name	X4 Pin
Opto. isol.	In ch 1	1	24 V	In ch 9	1
	In ch 2	2		In ch 10	2
	In ch 3	3		In ch 11	3
	In ch 4	4		In ch 12	4
	In ch 5	5		In ch 13	5
	In ch 6	6		In ch 14	6
	In ch 7	7		In ch 15	7
	In ch 8	8		In ch 16	8
	0V for in 1-8	9	0 V	0V for in 9-16	9
	Not used	10		Not used	10

NOTE!
The input current is 5.5 mA (at 24V) on the digital inputs. A capacitor connected to ground, to prevent disturbances, causes a short rush of current when setting the input. When connecting outputs, sensitive to pre-oscillation current, a serial resistor (100 Ω) may be used.

Signal name	X6 Pin	Explanation
AN_ICH1	1	For test purpose only
AN_ICH2	2	For test purpose only
0V	3	0V for In 1-2
0VA	4	0V for Out 1-2
AN_OCH1	5	Out ch 1
AN_OCH2	6	Out ch 2

3.16.6 Analog I/O DSQC 355 (optional)

The analog I/O unit provides following connections:

4 analog inputs, -10/+10V, which may be used for analog sensors etc.

4 analog outputs, 3 for -10/+10V and 1 for 4-20mA, for control of analog functions such as controlling gluing equipment etc.

24V to supply external equipment wich return signals to DSQC 355.

Technical data

See Product Specification IRB 6400, chapter 3.10.

Further information

For setup parameters, see User’s Guide, section System Parameters, Topic: Controller. Circuit diagram, see chapter 11.

CONNECTION TABLE
Customer contacts: X1, X3, X 5 - X8

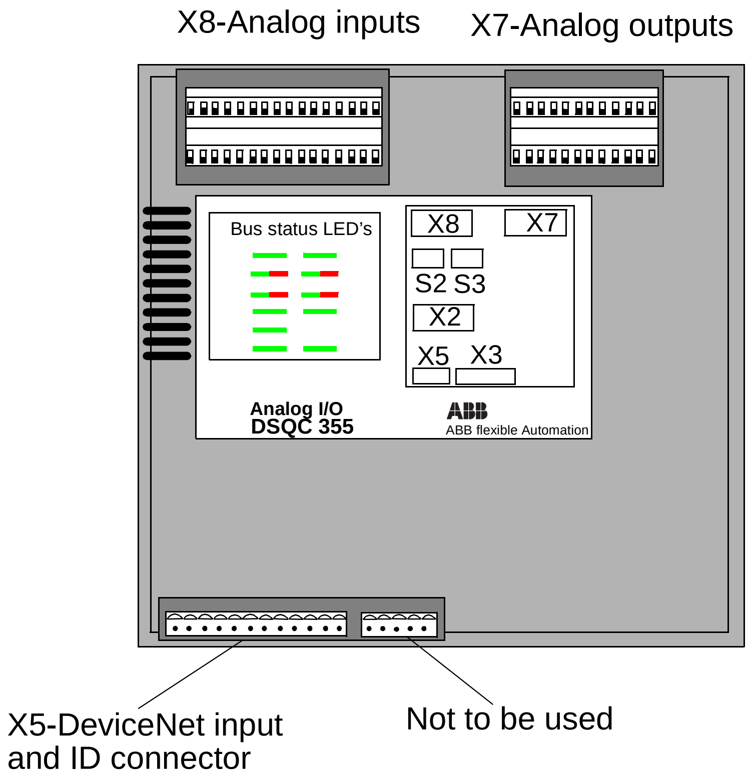
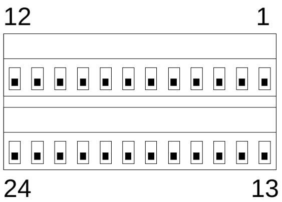


Figure 49 Analog I/O unit

Connector X5- DeviceNet connectors

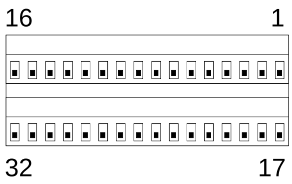
See section 3.16.3 on page 62.

Connector X7 - Analog outputs



	X7	
Signal name	**Pin**	**Description**
ANOUT_1	1	Analog output 1, -10/+10V
ANOUT_2	2	Analog output 2, -10/+10V
ANOUT_3	3	Analog output 3, -10/+10V
ANOUT_4	4	Analog output 4, 4-20 mA
Not to be used	5	
Not to be used	6	
Not to be used	7	
Not to be used	8	
Not to be used	9	
Not to be used	10	
Not to be used	11	
Not to be used	12	
Not to be used	13	
Not to be used	14	
Not to be used	15	
Not to be used	16	
Not to be used	17	
Not to be used	18	
GND	19	Analog output 1, 0 V
GND	20	Analog output 2, 0 V
GND	21	Analog output 3, 0 V
GND	22	Analog output 4, 0 V
GND	23	
GND	24	

Connector X8 - Analog inputs



Signal name	X8 Pin	Description
ANIN_1	1	Analog input 1, -10/+10 V
ANIN_2	2	Analog input 2, -10/+10 V
ANIN_3	3	Analog input 3, -10/+10 V
ANIN_4	4	Analog input 4, -10/+10 V
Not to be used	5	
Not to be used	6	
Not to be used	7	
Not to be used	8	
Not to be used	9	
Not to be used	10	
Not to be used	11	
Not to be used	12	
Not to be used	13	
Not to be used	14	
Not to be used	15	
Not to be used	16	
+24V out	17	+24VDC supply
+24V out	18	+24VDC supply
+24V out	19	+24VDC supply
+24V out	20	+24VDC supply
+24V out	21	+24VDC supply
+24V out	22	+24VDC supply
+24V out	23	+24VDC supply
+24V out	24	+24VDC supply
GND	25	Analog input 1, 0V
GND	26	Analog input 2, 0V
GND	27	Analog input 3, 0V
GND	28	Analog input 4, 0V
GND	29	
GND	30	
GND	31	
GND	32	

3.16.7 Encoder interface unit, DSQC 354

The encoder interface unit provides connections for 1 encoder and 1 digital input.

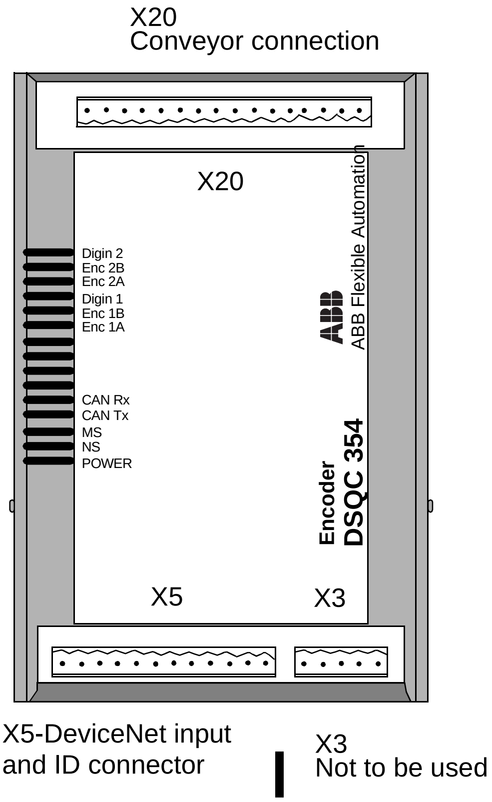
The encoder is used for installation on a conveyor to enable robot programs to synchronize to the motion (position) of the conveyor.

The digital input is used for external start signal/ conveyor synchronization point.

Further information

User Reference Description Conveyor Tracking.
For setup parameters, see User's Guide, section System Parameters, Topic: Controller.
Circuit diagram, see chapter 11.

Customer terminals:



Device Net connector X5, see section 3.16.3 on page 62

Figure 50 Encoder unit, DSQC 354

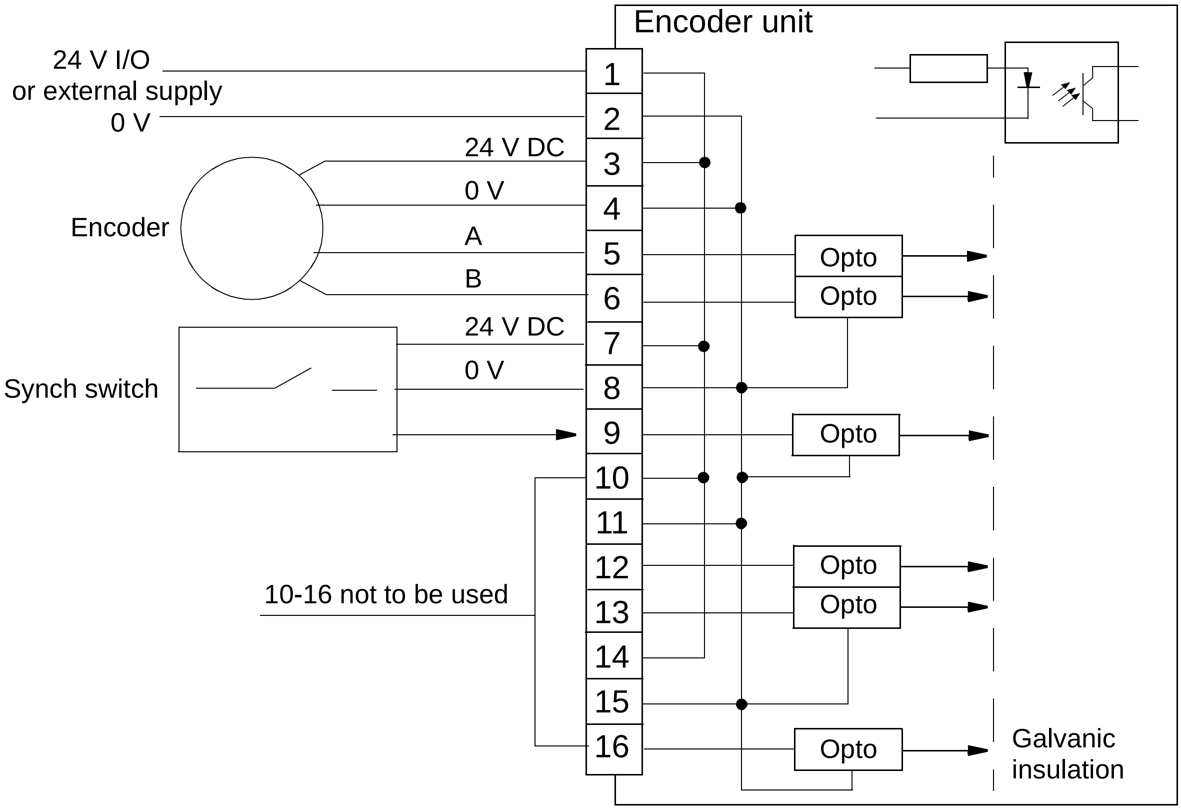
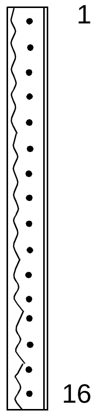


Figure 51 Encoder connections.

The wiring diagram in Figure 51 shows how to connect the encoder and start signal switch to the encoder unit. As can be seen from the illustration, the encoder is supplied with 24 VDC and 0V. The encoder output 2 channels, and the on-board computer uses quadrature decoding (QDEC) to compute position and direction.

Connector X20 - Encoder and digital input connections

		X20	
Input and ID	**Signal name**	**Pin**	**Description**
	24 VDC	1	24 VDC supply
	0 V	2	0 V
	ENC	3	Encoder 24 VDC
	ENC	4	Encoder 0 V
	ENC_A	5	Encoder Phase A
	ENC_B	6	Encoder Phase B
	DIGIN	7	Synch switch 24 VDC
	DIGIN	8	0V
	DIGIN	9	Synch switch digital input
	Not to be used	10	
	Not to be used	11	
	Not to be used	12	
	Not to be used	13	
	Not to be used	14	
	Not to be used	15	
	Not to be used	16	

3.16.8 Relay I/O DSQC 332

16 output relays each with a single Normal Open contact, independent of each other.

16 digital 24V inputs divided into groups of 8. The groups are galvanically isolated. Supply to customer switches can be taken either from the cabinet 24 V I/O or from a separate supply.

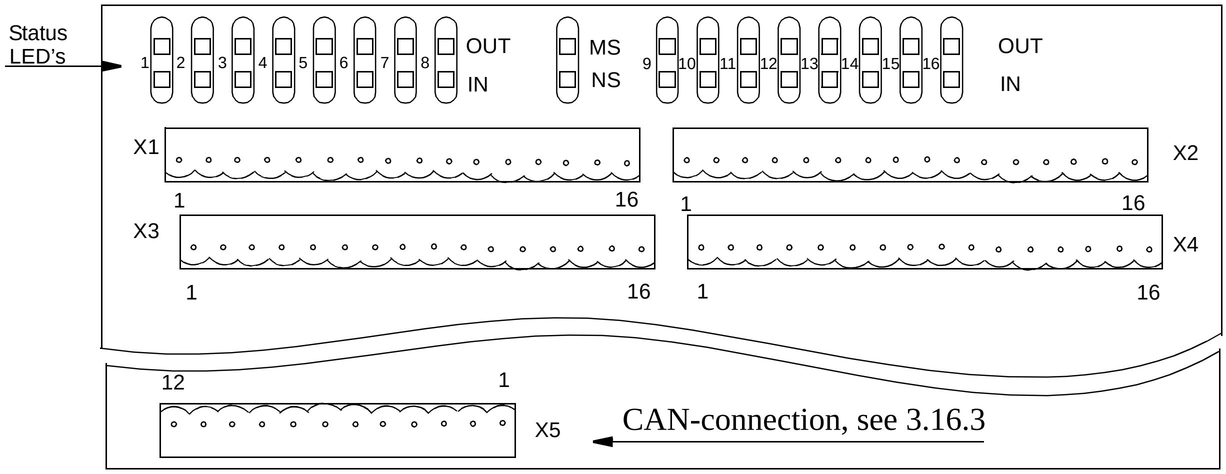
Technical data

See Product Specification IRB 6400, chapter 3.10.

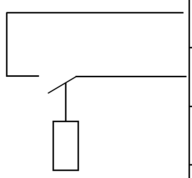
Further information

For setup parameters, see User's Guide, section System Parameters, Topic: Controller. Circuit diagram, see chapter 11.

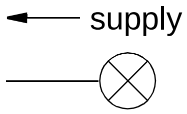
CONNECTION TABLE
Customer contacts: X1 - X4



Unit function



Customer conn.



	X1
Signal name	**Pin**
Out ch 1a	1
Out ch 1b	2
Out ch 2a	3
Out ch 2b	4
Out ch 3a	5
Out ch 3b	6
Out ch 4a	7
Out ch 4b	8
Out ch 5a	9
Out ch 5b	10
Out ch 6a	11
Out ch 6b	12
Out ch 7a	13
Out ch 7b	14
Out ch 8a	15
Out ch 8b	16

	X2
Signal name	**Pin**
Out ch 9a	1
Out ch 9b	2
Out ch 10a	3
Out ch 10b	4
Out ch 11a	5
Out ch 11b	6
Out ch 12a	7
Out ch 12b	8
Out ch 13a	9
Out ch 13b	10
Out ch 14a	11
Out ch 14b	12
Out ch 15a	13
Out ch 15b	14
Out ch 16a	15
Out ch 16b	16

		X3			**X4**
Unit function	**Signal name**	**Pin**	**Customer conn.**	**Signal name**	**Pin**
Opto. isol.	In ch 1	1	24 V	In ch 9	1
	In ch 2	2		In ch 10	2
	In ch 3	3		In ch 11	3
	In ch 4	4		In ch 12	4
	In ch 5	5		In ch 13	5
	In ch 6	6		In ch 14	6
	In ch 7	7		In ch 15	7
	In ch 8	8		In ch 16	8
	0V for in 1-8	9	0 V	0V for in 9-16	9
	Not used	10		Not used	10
	Not used	11		Not used	11
	Not used	12		Not used	12
	Not used	13		Not used	13
	Not used	14		Not used	14
	Not used	15		Not used	15
	Not used	16		Not used	16

NOTE!
The input current is 5.5 mA (at 24V) on the digital inputs. A capacitor connected to ground, to prevent disturbances, causes a short rush of current when setting the input. When connecting a source (PLC), sensitive to pre-oscillation current, a serial resistor (100 Ω) may be used.

3.16.9 Digital 120 VAC I/O DSQC 320

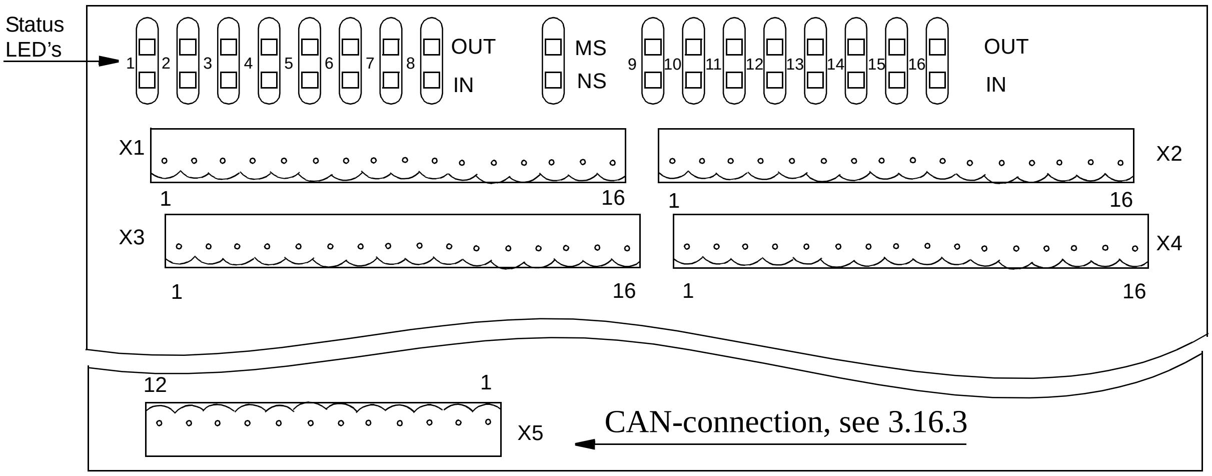
Technical data

See Product Specification IRB 6400, chapter 3.10.

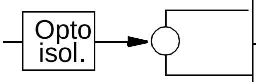
Further information

For setup parameters, see User's Guide, section System Parameters, Topic: Controller.
Circuit diagram, see chapter 11.

CONNECTION TABLE
Customer contacts: X1 - X4

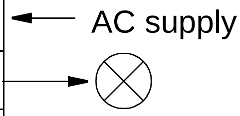


Unit function

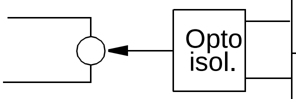


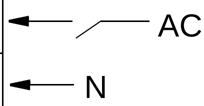
	X1
Signal name	**Pin**
Out ch 1a	1
Out ch 1b	2
Out ch 2a	3
Out ch 2b	4
Out ch 3a	5
Out ch 3b	6
Out ch 4a	7
Out ch 4b	8
Out ch 5a	9
Out ch 5b	10
Out ch 6a	11
Out ch 6b	12
Out ch 7a	13
Out ch 7b	14
Out ch 8a	15
Out ch 8b	16

Customer conn.



	X2
Signal name	**Pin**
Out ch 9a	1
Out ch 9b	2
Out ch 10a	3
Out ch 10b	4
Out ch 11a	5
Out ch 11b	6
Out ch 12a	7
Out ch 12b	8
Out ch 13a	9
Out ch 13b	10
Out ch 14a	11
Out ch 14b	12
Out ch 15a	13
Out ch 15b	14
Out ch 16a	15
Out ch 16b	16





Unit function	Signal name	X3 Pin	Customer conn.	Signal name	X4 Pin
	In ch 1a	1		In ch 9a	1
	In ch 1b	2		In ch 9b	2
	In ch 2a	3		In ch 10a	3
	In ch 2b	4		In ch 10b	4
	In ch 3a	5		In ch 11a	5
	In ch 3b	6		In ch 11b	6
	In ch 4a	7		In ch 12a	7
	In ch 4b	8		In ch 12b	8
	In ch 5a	9		In ch 13a	9
	In ch 5b	10		In ch 13b	10
	In ch 6a	11		In ch 14a	11
	In ch 6b	12		In ch 14b	12
	In ch 7a	13		In ch 15a	13
	In ch 7b	14		In ch 15b	14
	In ch 8a	15		In ch 16a	15
	In ch 8b	16		In ch 16b	16

3.17 Gateway (Field bus) units

3.17.1 RIO (Remote Input Output), remote I/O for Allen-Bradley PLC DSQC 350

The RIO-unit can be programmed for 32, 64, 96 or 128 digital inputs and outputs.

The RIO-unit should be connected to an Allen-Bradley PLC using a screened, two conductor cable.

Technical data

See Product Specification IRB 6400, chapter 3.10 and Allen-Bradley RIO specification.

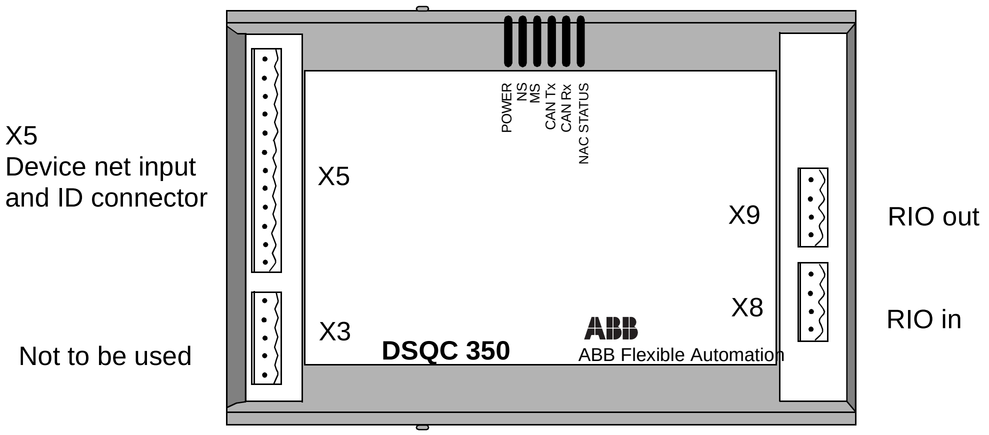
Further information

For setup parameters, see User's Guide, section System Parameters, Topic: Controller. Circuit diagram, see chapter 11.

Customer terminals: X8 and X9

	X8	
Signal name	**Pin**	
LINE1 (blue)	1	Remote I/O in
LINE2 (clear)	2	
shield	3	
cabinet ground	4	

	X9	
Signal name	**Pin**	
blue	1	Remote I/O out
clear	2	
shield	3	
cabinet ground	4	



Device Net connector X5, see section 3.16.3 on page 62

Figure 52 RIO-unit

When the robot is last in a RIO loop, the loop must be terminated with a termination resistor according to Allen-Bradley's specification.

This product incorporates a communications link which is licensed under patents and proprietary technology of Allen-Bradley Company, Inc. Allen-Bradley Company, Inc. does not warrant or support this product. All warranty and support services for this product are the responsibility of and provided by ABB Flexible Automation.

RIO communication concept

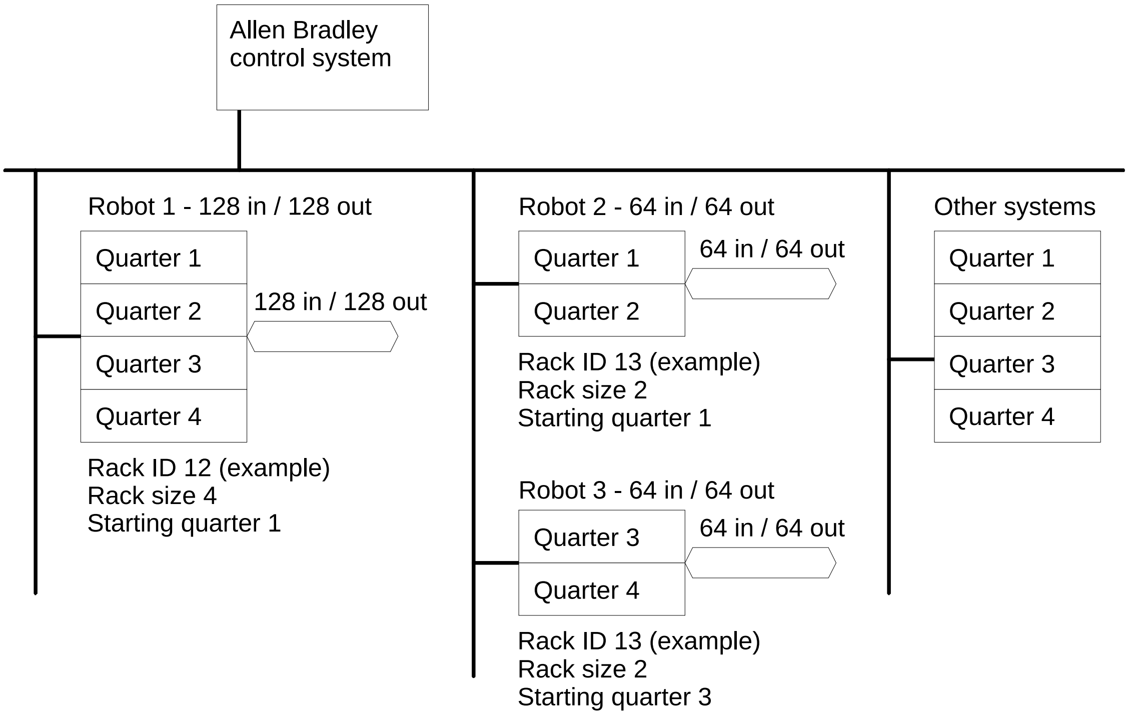


Figure 53 RIO communication concept - Principle diagram

The Allen Bradley system can communicate with up to 64 external systems. Each of these systems is called a Rack and is given a Rack Address 0-63. Basically, each robot connected to the Allen Bradley system will occupy 1 rack.

Each rack is divided into 4 sections called Quarters. Each quarter provides 32 inputs and 32 outputs and a rack will subsequently provide 128 inputs and 128 outputs.

A rack may also be shared by 2, 3 or 4 robots. Each of these robots will then have the same rack address, but different starting quarters must be specified.

The illustration above shows an example where Robot 1 uses a full rack while robot 2 and robot 3 share 1 rack.

The rack address, starting quarter and other required parameters such as baud rate, LED Status etc. are entered in the configuration parameters.

The robot may communicate with the Allen Bradley system only, or be used in combination with I/O system in the robot. For example, the inputs to the robot may come from the Allen Bradley system while the outputs from the robot control external equipment via general I/O addresses and the Allen Bradley system only reads the outputs as status signals.

3.17.2 Interbus-S, slave DSQC 351

The unit can be operated as a slave for a Interbus-S system.

Technical data

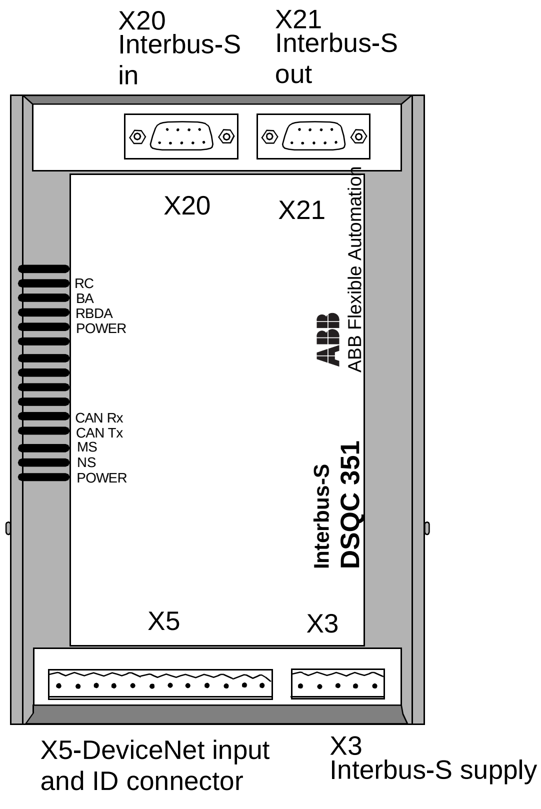
See Interbus-S specification.

Further information

For setup parameters, see User’s Guide, section System Parameters, Topic: Controller. Circuit diagram, see chapter 11.

Unit ID to be entered in the Interbus-S master is 3. The length code depends on the selected data. Width between 1 and 4.

Customer terminals: see figure below regarding locations.



Device Net connector X5, see section 3.16.3 on page 62

Figure 54 Interbus-S, DSQC 351

Communication concept

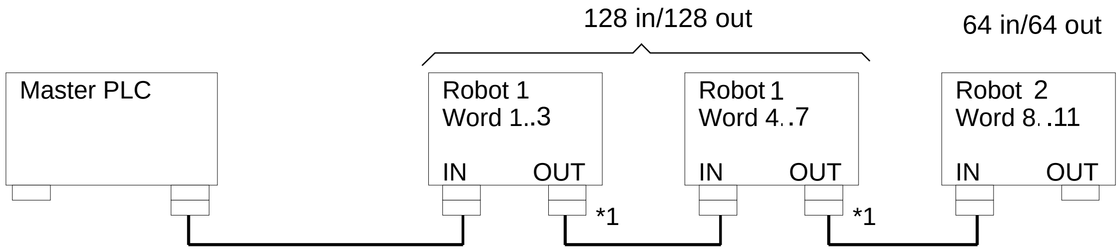
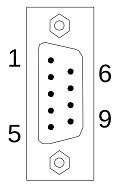


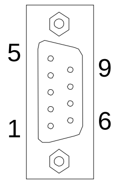
Figure 55 Outline diagram.

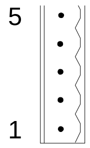
The Interbus-S system can communicate with a number of external devices, the actual number depends on the number of process words occupied of each unit. The robot can be equipped with one or two DSQC 351. The Interbus-S inputs and outputs are accessible in the robot as general inputs and outputs.

For application data, refer to Interbus-S, International Standard, DIN 19258.

***1**
Note that there is a link between pin 5 and 9 in the plug on interconnection cable which is connected to the OUT connector for each unit. The link is used to inform the Interbus-S unit that more units are located further out in the chain. (The last unit in the chain does not have cable connected and thereby no link).

		X20	
Interbus-S IN	**Signal name**	**Pin**	**Description**
	TPDO1	1	Communication line TPDO1
	TPDI1	2	Communication line TPDI1
	GND	3	Ground connection
	NC	4	Not connected
	NC	5	Not connected
	TPDO1-N	6	Communication line TPDO1-N
	TPDI1-N	7	Communication line TPDI1-N
	NC	8	Not connected
	NC	9	Not connected

Interbus-S OUT	Signal name	X21 Pin	Description
	TPDO2	1	Communication line TPDO2
	TPDI2	2	Communication line TPDI2
	GND	3	Ground connection
	NC	4	Not connected
	+5V	5	+5VDC
	TPDO2-N	6	Communication line TPDO2-N
	TPDI2-N	7	Communication line TPDI2-N
	NC	8	Not connected
	RBST	9	Synchronization

Interbus-S supply	Signal name	X3 Pin	Description
	0 V DC	1	External supply of Interbus-S
	NC	2	Not connected
	GND	3	Ground connection
	NC	4	Not connected
	+ 24 V DC	5	External supply of Interbus-S

NOTE! External supply is recommended to prevent loss of fieldbus at IRB power off.

3.17.3 Profibus-DP, slave, DSQC352

The unit can be operated as a slave for a Profibus-DP system.

Technical data

See Profibus-DP specification, DIN E 19245 part 3.

Further information

For setup parameters, see User's Guide, section System Parameters, Topic: IO Signals. Circuit diagram, see chapter 11.

Customer connections

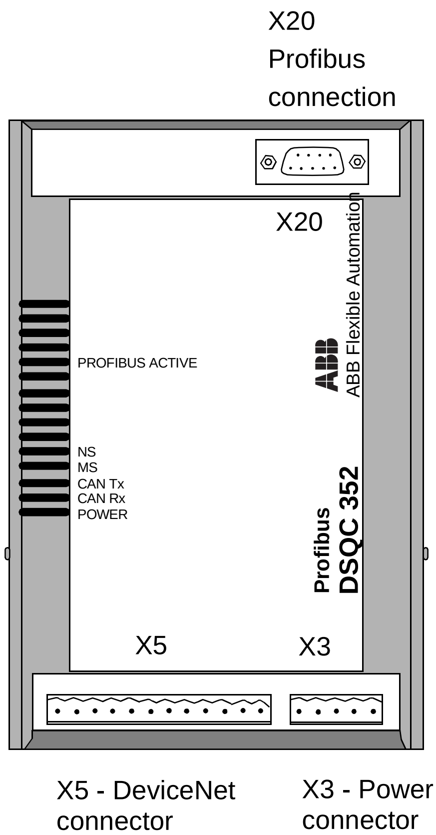


Figure 56 DSQC352, location of connectors

Communication concept

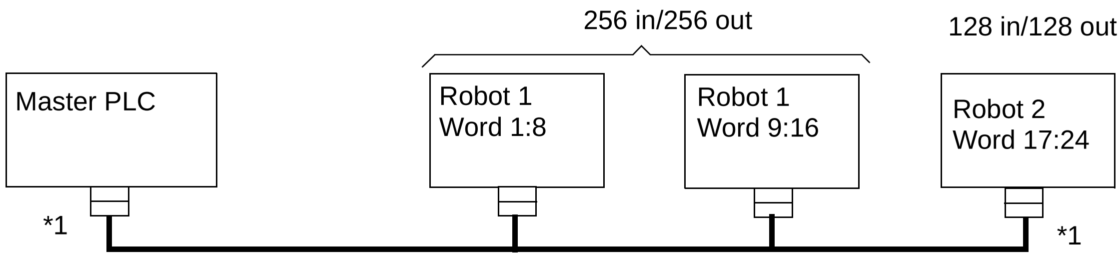
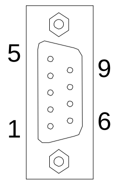


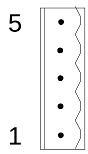
Figure 57 Profibus-DP communication concept

The Profibus-DP system can communicate with a number of external devices. The actual number depends on the number of process words occupied of each unit. The robot can be equipped with one or two DSQC352. The Profibus-DP inputs and outputs are accessible in the robot as general inputs and outputs.

For application data, refer to Profibus-DP, International Standard, DIN 19245 Part 3.

*1 - Note that the Profibus cable must be terminated in both ends.

		X20	
Profibus-DP	**Signal name**	**Pin**	**Description**
	Shield	1	Cable screen
	NC	2	Not connected
	RxD/TxD-P	3	Receive/Transmit data P
	Control-P	4	
	GND	5	Ground connection
	+ 5V DC	6	
	NC	7	Not connected
	Rxd/TxD-N	8	Receive/Transmit data N
	NC	9	Not connected

		X3	
Profibus-DP supply	**Signal name**	**Pin**	**Description**
	0 V DC	1	External supply of Profibus-DP
	NC	2	Not connected
	GND	3	Ground connection
	NC	4	Not connected
	+ 24 V DC	5	External supply of Profibus-DP

Device Net connector X5, see section 3.16.3 on page 62.

3.18 Communication

3.18.1 Serial links, SIO

The robot has two serial channels, which can be used by the customer to communicate with printers, terminals, computers and other equipment (see Figure 58).

The serial channels are:

- SIO1-
  RS 232 with RTS-CTS-control and support for XON/XOFF,
  transmission speed 300 - 19 200 baud.
- SIO2-
  RS 422 full duplex TXD4, TXD4-N, RXD4, RXD4-N,
  transmission speed 300 - 19 200 baud.

Further information

For setup parameters, see User's Guide, section System Parameters, Topic: Controller.
Circuit diagram, see chapter 11.
Product Specification IRB 2400, chapter 3.10.
Separate documentation is included when the option RAP Serial link is ordered.

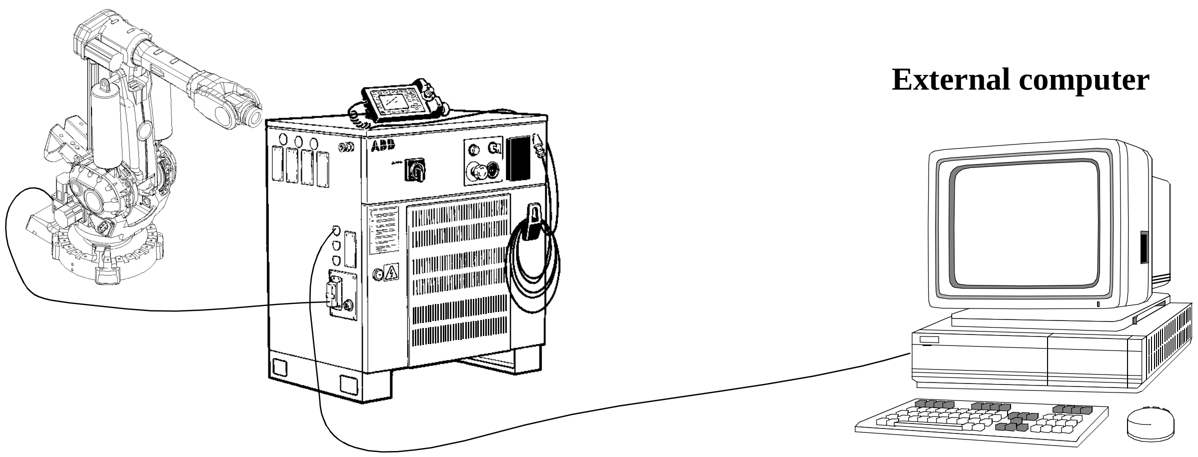


Figure 58 Serial channels, SLIP, outline diagram.

Customer terminals, on controller backplane:X1(SIO1) and X2(SIO2), see 3.7.

Two variants exits depending on backplane type.

Cable connectors with screwed connections (not supplied), type Phönix Combicon MSTTBVA 2.5/12-6-5.08. Keying of board connector according to circuit diagram, chapter 11.

DSCQ 330 (screw terminals)

X1	
Pin	**Signal**
1	TXD
2	RTS N
3	0V
4	RXD
5	CTS N
6	0V
7	DTR
8	DSR
9	0V
10	
11	
12	

X2	
Pin	**Signal**
1	TXD
2	TXD N
3	0V
4	RXD
5	RXD N
6	0V
7	DATA
8	DATA N
9	0V
10	DCLK
11	DCLK N
12	0V

DSQC 369 (D-sub connectors)

X1	
Pin	**Signal**
1	
2	RXD
3	TXD
4	DTR
5	0 V
6	DSR
7	RTS N
8	CTS N
9	

X2	
Pin	**Signal**
1	TXD
2	TXD N
3	RXD
4	RXD N
5	0 V
6	DATA
7	DATA N
8	DCLK
9	DCLK N

Explanation of signals:
TXD=Transmit Data, **RTS**=Request To Send, **RXD**=Receive Data, **CTS**=Clear To Send, **DTR**=Data Terminal Ready, **DSR**=Data Set Ready, **DATA**=Data Signals in Half Duplex Mode, **DCLK**=Data Transmission Clock.

3.18.2 Ethernet communication, DSQC 336

The ethernet communication board has two options for ethernet connection.

Connector X4 is used for connection of twisted-pair Ethernet (TPE), or as defined in IEEE 802.3 : 10BASE-T. Maximum node-to-node distance 100 meter. The ethernet communication board has no termination for cable screen. Cable screen must be grounded at cabinet wall with a cable gland. 10BASE-T is a point-to-point net, connected via a HUB.

Connector X11 is used for connection of transceivers with AUI (Attachment Unit Interface). Typical use of this connector is connection of transceivers for 10BASE2 (CheaperNet, Thinnet, Thinwire Enet, - 0.2 inch, 50 ohm coax with BNC connector) or optical fibre net. Note the environmental conditions for the transceiver inside the controller, i.e. +70^{o} C.

Technical data

See Ethernet specification.

Further information

For setup parameters, see User’s Guide, section System Parameters, Topic: Controller.
Circuit diagram, see chapter 11.
Separate documentation is included when the option Ethernet services is ordered.

Customer terminals, on board front: X4 and X11

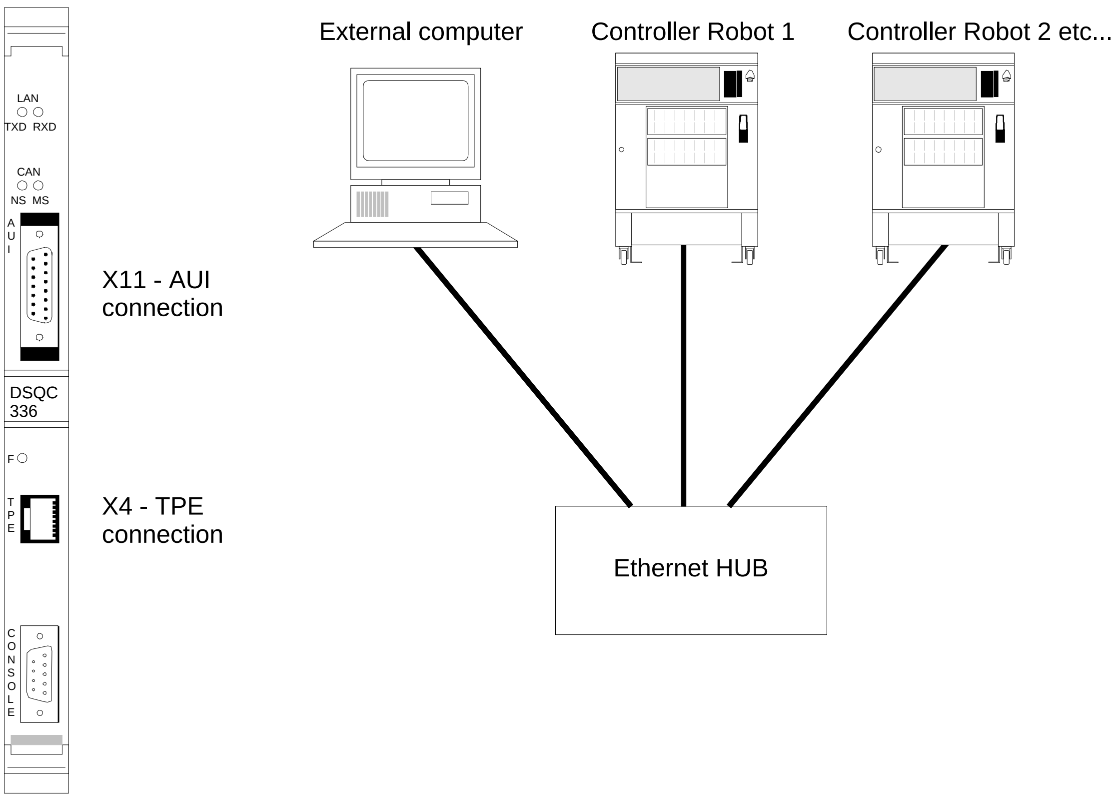
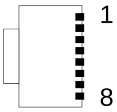


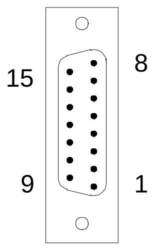
Figure 59 Ethernet TCP/IP, outline diagram.

Connector X4 - Ethernet TPE connector



	X4	
Signal name	**Pin**	**Description**
TPTX+	1	Transmit data line +
TPTX-	2	Transmit data line -
TPRX+	3	Receive data line +
NC	4	Not connected
NC	5	Not connected
TPRX-	6	Receive data line -
NC	7	Not connected
NC	8	Not connected

Connector X11 - Ethernet AUI connector



	X11	
Signal name	**Pin**	**Description**
GND	1	Ground connection
COLL+	2	Collision detection line +
TXD+	3	Transmit data line +
GND	4	Ground connection
RXD+	5	Receive data line +
GND	6	Ground connection
NC	7	Not connected
GND	8	Ground connection
COLL-	9	Collision detection line -
TXD-	10	Transmit data line -
GND	11	Ground connection
RXD-	12	Receive data line -
+12V	13	+12VDC
GND	14	Ground connection
NC	15	Not connected

3.19 External operator's panel

All necessary components are supplied, except for the external enclosure.

The assembled panel must be installed in a housing which satisfies protection class, IP 54, in accordance with IEC 144 and IEC 529.

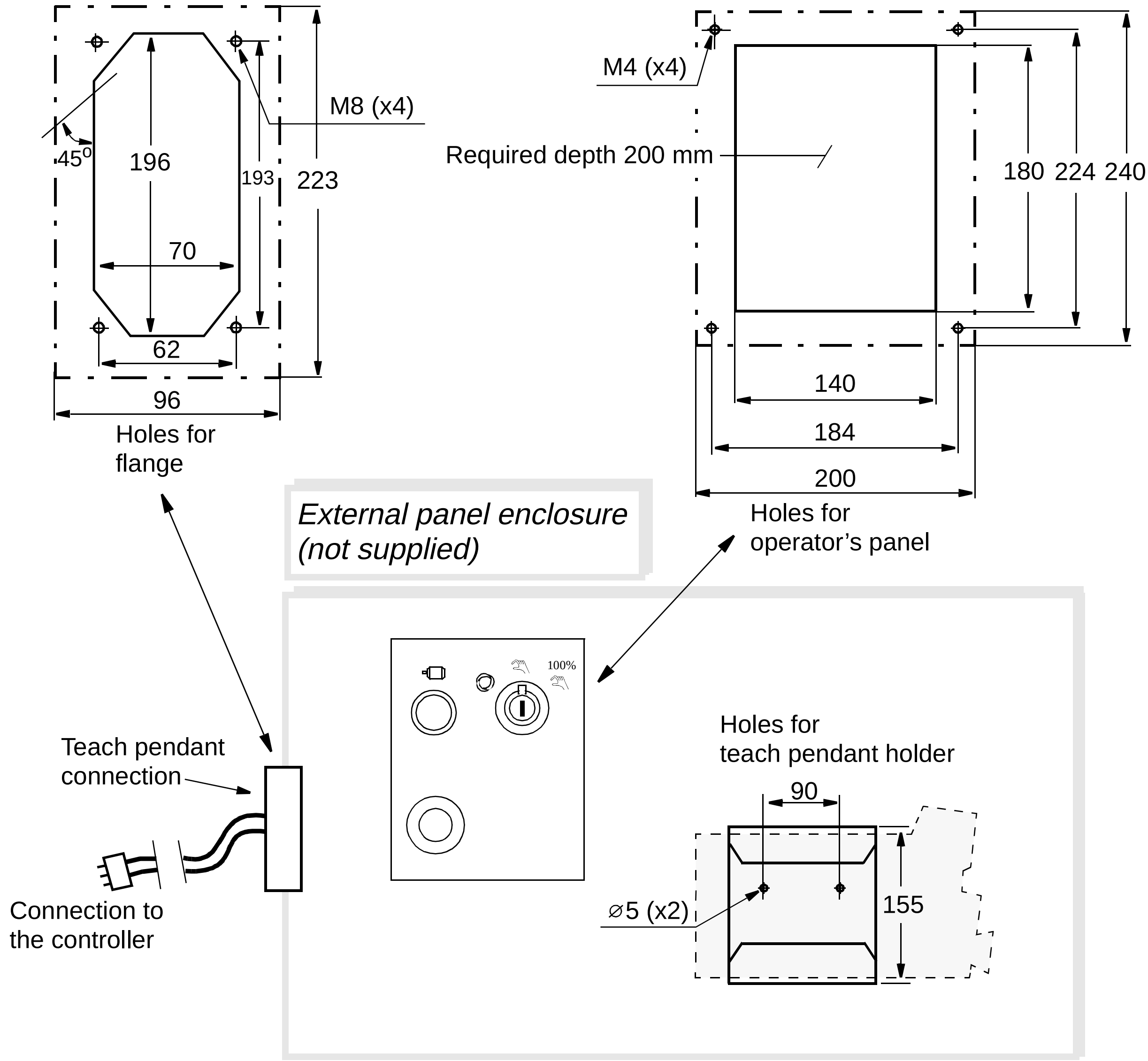


Figure 60 Required preparation of external panel enclosure.

4 Installing the Control Program

The robot memory is battery-backed, which means that the control program and settings (pre-installed) are saved when the power supply to the robot is switched off.

The robot might be delivered without software installed and the memory back-up batteries disconnected to ensure maximum battery capacity after installation.
If so, connect the batteries and start the installation according to 4.1.1.

4.1 System diskettes

- **Key disk** (one disk)
  Each robot needs an unique key disk with selected options and IRB type.
  Robots within the same family (i.e. different variants of the robot) can use the same key disk with a licence number.
- **System pack**
  BaseWare OS, all options and ProcessWare.
- **Controller parameters** (one disk)
  At delivery, it includes I/O configuration according to order specification.
  At commissioning all parameters are stored.
- **Manipulator parameters** (one disk)
  Includes sync. offsets from manufacturing calibration.

4.1.1 Installation procedure

1. Perform a cold start on the system.

2. Insert the “Key disk” when displayed on the teach pendant.

3. Follow information displayed on the teach pendant. Keep attention to prompted System pack disk number (all diskettes are not used at the same installation).

During the installation following menus appears:

- **Silent** = The installation follows the information on the Key disk.
- **Add Opt** = The installation follows the Key disk but further options, not included in the system pack, are possible to add.
- **Query** = Questions about changing language, robot type (within the same family), gain access to service mode, see User’s Guide, System Parameters etc. are coming up. Makes it possible to exclude options but not add more than included in the Key disk.

If Query is selected, make sure that the correct robot type is entered. If not, this will affect the safety function *Reduced speed 250 mm/s*.

If Query is selected, make sure that all required options are installed. Note that some of these options also require installation of other options. Rejecting of proposed options during installation may cause an incomplete robot installation.

4. The robot performs a warm start when installation is finished.

Wait until the welcome window appears on the display before doing anything. The warm start can take up to 2 minutes after the installation display ready.

5. Load the specific installation parameters from the Controller Parameter disk or corresponding.

After the control program has been installed, the diskettes should be stored in a safe place in accordance with the general rules for diskette storage. Do not store the diskettes inside the controller to avoid damaged from heat and magnetic fields.

6. Conclude the installation with updating the revolution counters according to section 2.13.2.

4.1.2 Query mode questions about used DC-links and balancing units

If query installation is selected, you will get a question about used DC-link. You will find the article number for the DC-link on the unit inside the controller.

Type	Art. no.	Config id	Description
DSQC 345A	3HAB 8101-1	DC0	DC-link
DSQC 345B	3HAB 8101-2	DC1	DC-link
DSQC 345C	3HAB 8101-3	DC2	DC-link
DSQC 345D	3HAB 8101-4	DC3	DC-link, step down
DSQC 358C	3HAB 8101-10	DC2T	DC-link + single drive unit
DSQC 358E	3HAB 8101-12	DC2C	DC-link + single drive unit

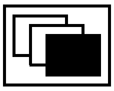
For IRB 6400R you will also get a question on what type of balancing units that is used. For identification, please see label attached at the top of the units.

4.2 Calibration of the manipulator

Calibrate the manipulator according to section 2.13.

4.3 Cold start

To install the control program in a robot already in operation the memory must be emptied. Besides disconnecting the batteries for a few minutes, the following method can be used:

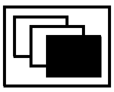
1. Select the Service window 
2. Select **File: Restart**
3. Then enter the numbers 1 3 4 6 7 9
4. The fifth function key changes to **C-Start** (Cold start)
5. Press the key **C-Start**

It will take quite some time to perform a Cold start. Just wait until the robot starts the Installation dialog, see 4.1.1.

Do not touch any key, joystick, enable device or emergency stop until you are prompted to press any key.

4.4 How to change language, options and IRB types

(Valid for robots within the same family)

1. Select the Service window 
2. Select **File: Restart**
3. Enter the numbers 1 4 7
4. The fifth function key changes to **I-Start**

Note!
Make sure that the **disk 3** from the System pack is inserted when installing BaseWare OS Plus or **disk 5** when installing BaseWare OS.

5. Press the key **I-Start**
6. Continue with following the text on the teach pendant.

4.5 How to use the disk, Manipulator Parameters

The S4C controller does not contain any calibration information at delivery (Robot Not Calibrated shown on the teach pendant).

Once the Manipulator Parameter disk contents has been loaded to the controller as in one of the two cases described below, should a new parameter back-up be saved on the disk, **Controller Parameter**.
After saving the new parameters on the disk, **Controller Parameter** the **Manipulator Parameter** disk is no longer needed.

4.5.1 Robot delivered with software installed

In this case the basic parameters are already installed.

Load the calibration offset values from the disk, **Manipulator Parameters**.

1. Select **File: Add** or **Replace Parameter**.

Do not select Add new or **Load Saved Parameters.**

2. Press *OK*.

3. Save the new parameters according to section 4.6.

4.5.2 Robot delivered without software installed

In this case a complete cold start is necessary, remember to connect the back-up batteries.

The basic parameters are loaded at the cold start. The delivery specific I/O configuration is loaded from the disk, **Controller Parameters.**

1. Select **File:Add New Parameters**.

2. Press *OK*.

3. Load the calibration offset values from the disk, **Manipulator Parameters**.

4. Select **File:Add** or **Replace Parameter**.

Do not select Add new or **Load Saved Parameters.**

5. Press *OK*.

6. Save the new parameters according to section 4.6.

4.6 Saving the parameters on the Controller Parameter disk

1. Insert the disk, **Controller Parameter**.

2. Select **File:Save All As**.

For more detailed information regarding saving and loading parameters see User's Guide, System Parameters.

5 External Axes

5.1 General

External axes are controlled by internal or external (equals to non ABB) drive units. Internal drive units are mounted either inside the robot cabinet or in a separate external cabinet. External drive units are mounted in a user designed cabinet.

A maximum number of 6 external axes can be controlled by S4C. Internal drive units mounted in a separate cabinet cannot be combined with external drive units.

The drive and measurement systems each consist of two systems. Each system is connected to the CPU boards via a serial communication link.

A number of template configuration files are supplied with the system. The configuration files are optimum designed concerning system behaviour and performance of the axes. When installing external axes it is important to design installations, so a combination of standard files can be used.

Axes connected to Measurement System 1 can use Drive System 2 and vice versa. Allowed combinations - see configuration files section 5.3.5.

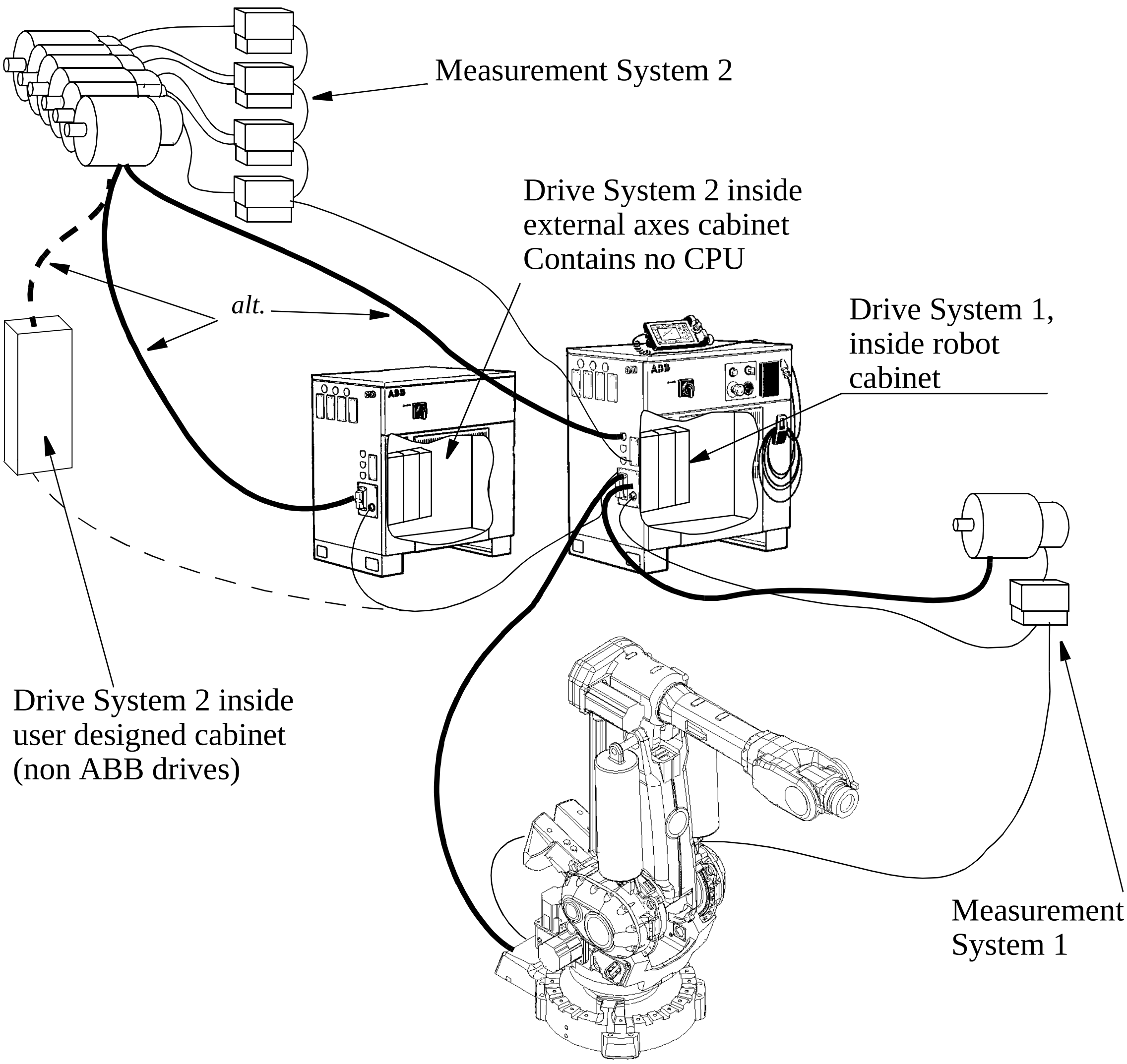


Figure 61 Outline diagram, external axes.

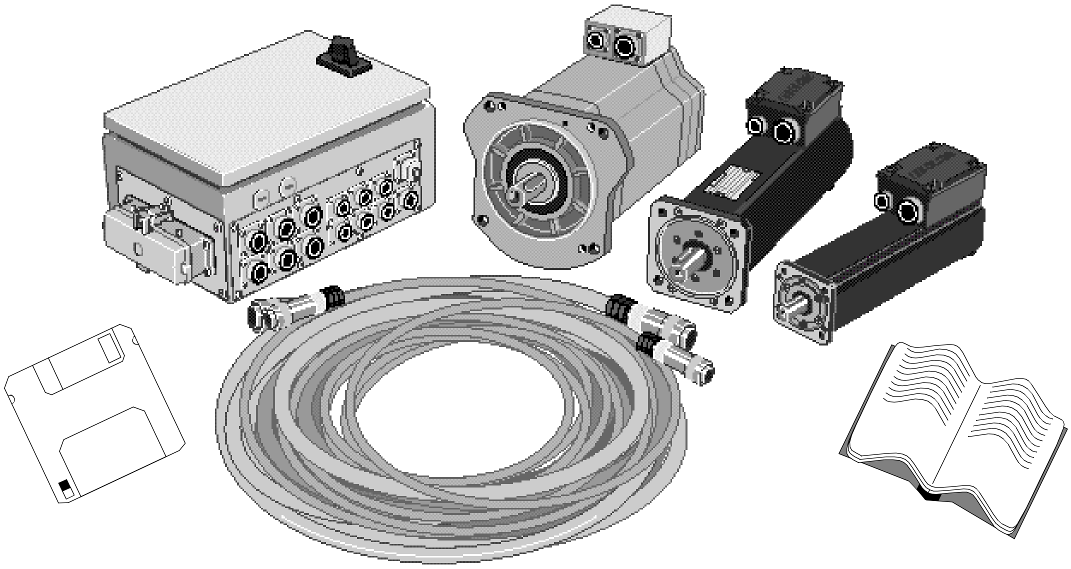
One extra serial measurement board (SMB) can be connected to Measurement System 1 and up to four to Measurement System 2. See Figure 61. One of the extra serial measurement boards of system 2 can be located inside the robot cabinet.

Max one external axis can be connected to Drive System 1. This axis is connected to the drive unit located in the DC-link. Up to six external axes can be connected to Drive System 2. Drive System 2 is in most cases located in a separate external cabinet.

For robots using only two drive units, as IRB1400 and IRB2400, a drive system 2 can be located in the robot cabinet. This mixed system is called Drive System 1.2 . Two axes can be connected to the drive module. In this case no external drive units or internal drive units mounted in a separate cabinet can be used.

5.2 Easy to use kits

A number of easy to use kits are available by ABB Flexible Automation AB. These kits contain all parts needed to install and operate external axes.



The kit contains:

- Motor/motors with brake and resolver. Different sizes of motors available.
- Gear boxes.
- Connection box with serial measurement board, manual brake release and terminal block for limit switches.
- All cables with connectors.
- Configuration file for easy software installation.
- Documentation

For more information see Product Specification Motor Unit from ABB Flexible Automation documentation.

5.3 User designed external axes.

5.3.1 DMC-C

Atlas Copco Controls stand alone servo amplifier DMC-C can be connected to Drive System 2, see Figure 62. Total of max 6 external axes can be installed.

.

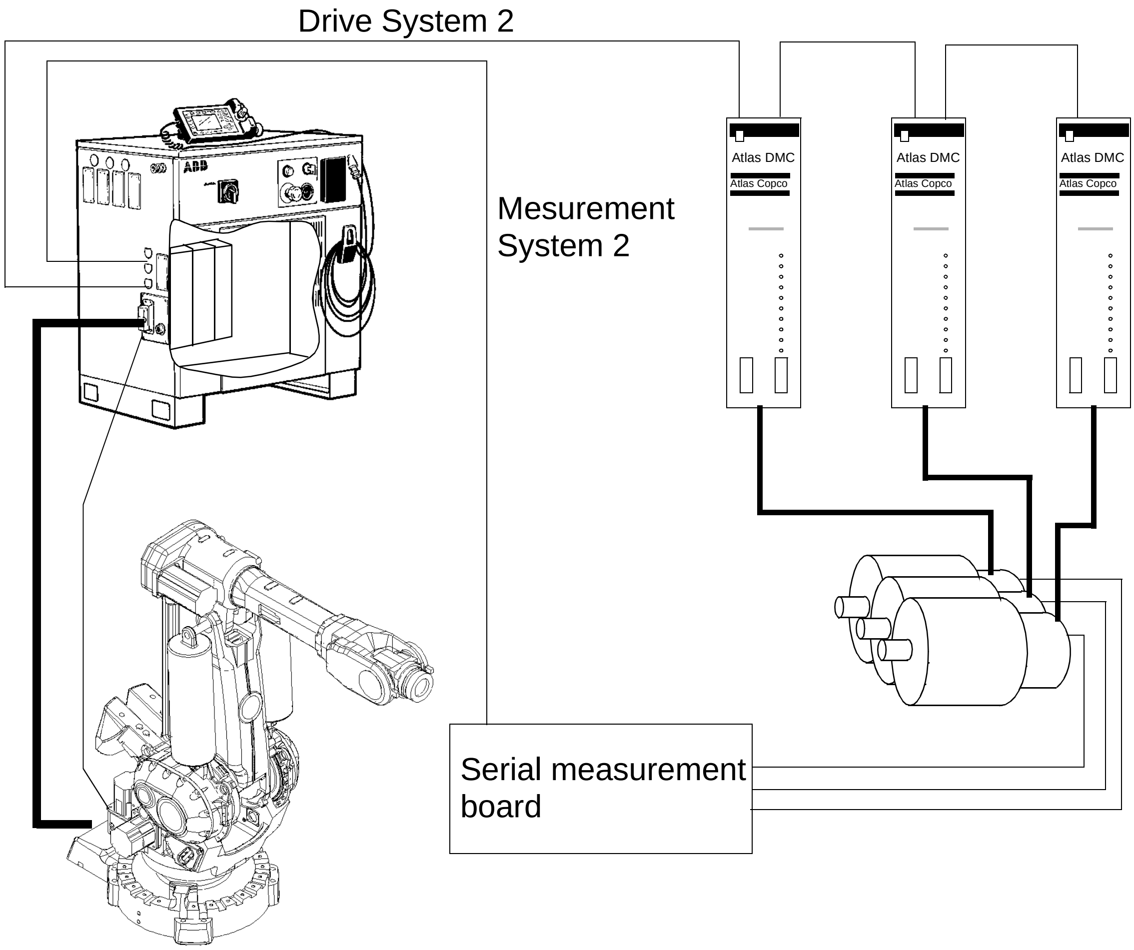


Figure 62 Servo amplifier, DMC.

Atlas Copco Controls provides the information on suitable motors and how to make installation and commissioning,

5.3.2 FBU

Atlas Copco Controls FBU (Field Bus Unit) can handle up to 3 external drive units, see Figure 63.

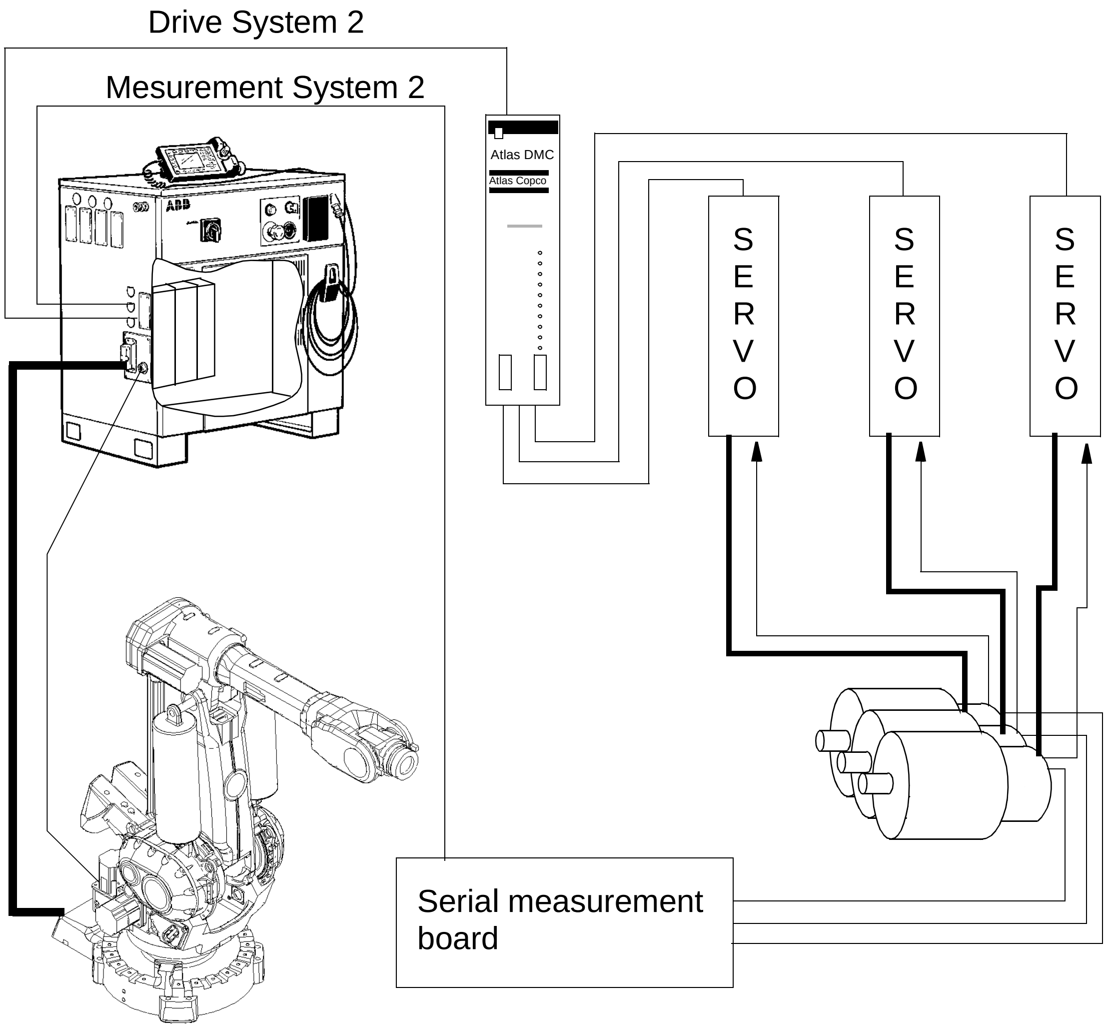


Figure 63 Field bus unit, FBU.

The drive units can be connected to analog speed reference outputs (+/- 10 V) or a field bus.

For further information about DMC-C and FBU contact Atlas Copco Controls.

5.3.3 Measurement System

There are two measurement system systems, 1 and 2. Each system is connected to the CPU board via a serial link. The serial link is of ring type with board 1 connected to CPU-board serial output. The last Serial Measurement Board (SMB) is connected to the CPU-board serial input.This link also supplies power to the SMB.

Measurement System 1 can consist of up to two SMB, one used for the robot manipulator, the other one for one external axis, normally a track motion. The external axis must be connected to node 4 and in the configuration file be addressed as logical node 7.

Measurement System 2 can consist of one to four SMB boards. The board numbering always starts with board 1. No gaps may occur in the number sequence. Every axis connected to a measuring system must have an unique node number. While the node number is the same as physical connection, the physical connection node must also be unique.

Each SMB has 6 connection nodes for resolvers. A battery supplies the SMB with power during power fail. If the axes move during power fail the internal revolution counters are automatically updated. After power on the system is ready for operation without any synchronization procedure.

A special configuration can be used with no robot connected. Only Measurement System 1 with one or two SMB may be used. Up to 6 external axes can be connected to those boards. See configuration files in Figure 77.

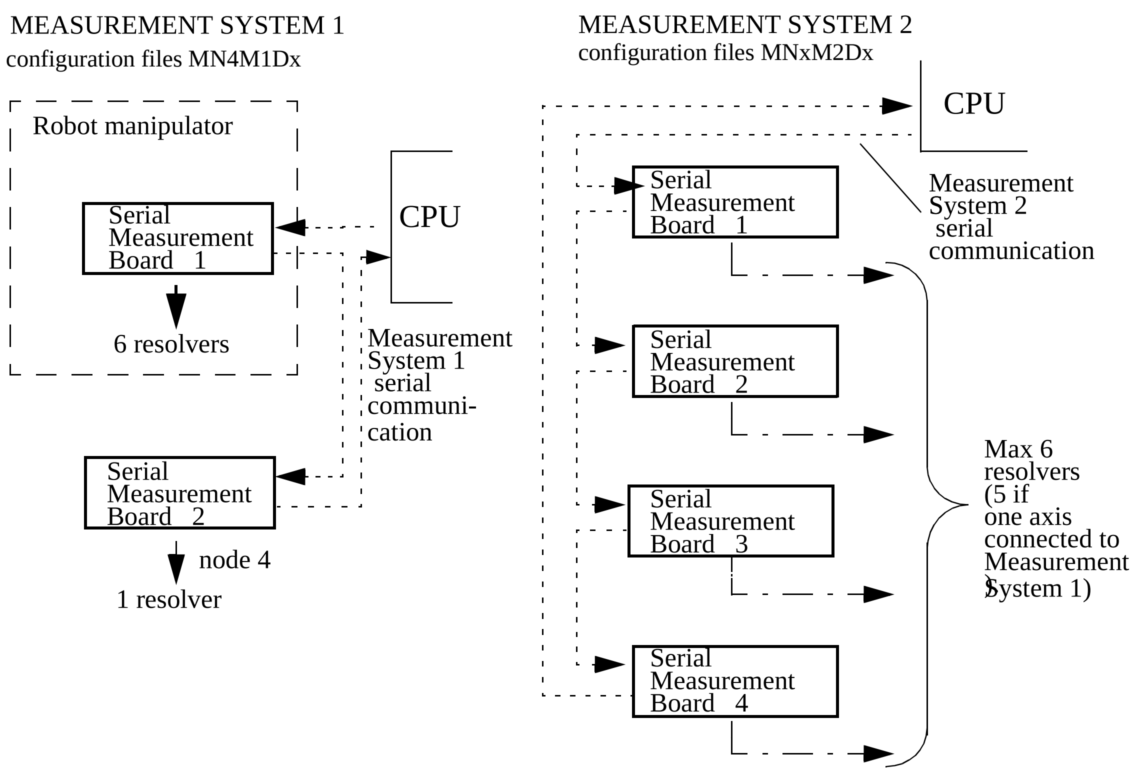


Figure 64 Measurement systems.

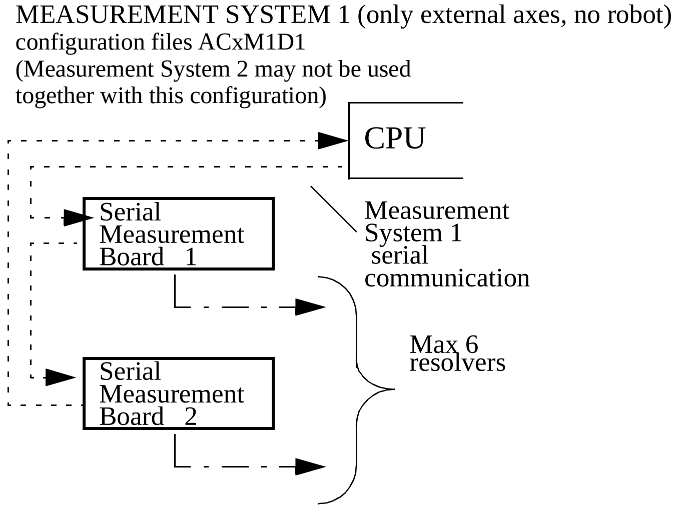


Figure 65 Measurement system 1.

Resolver

Each resolver contains two stators and one rotor, connected as shown in Figure 66.

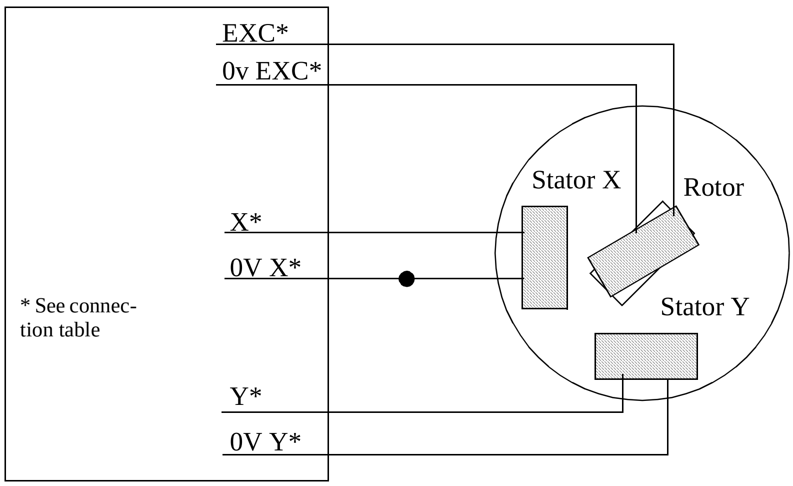


Figure 66 Connections for resolvers.

Technical data

Resolver	Integrated in motor of IRB type or art.no. 5766 388-5, size 11 Resolver must be approved by ABB for reliable operation.
Motor to resolver gear ratio	1:1, direct drive
Resolver cable length:	max 30 m (X, Y for each resolver) total max 70 m for EXC signals.

Cable: AWG 24, max 55pF/m, with shield.

The X, Y, 0V X and 0 V Y signals are used to connect resolvers to a serial measurement board.

The EXC, 0V EXC are used for common supply for all resolvers, parallel connected.

It is very important that the noise level on the measurement signals from the external axes is kept as low as possible, to prevent bad performance. Correct shielding and ground connections of cables, measurement boards and resolvers is essential.

The cabling must comply with signal class “measurement signals” (see chapter 3.1, Signal classes).

The enclosure for external serial measurement board(s) must comply with enclosure class IP 54, in accordance with IEC 144 and IEC 529.

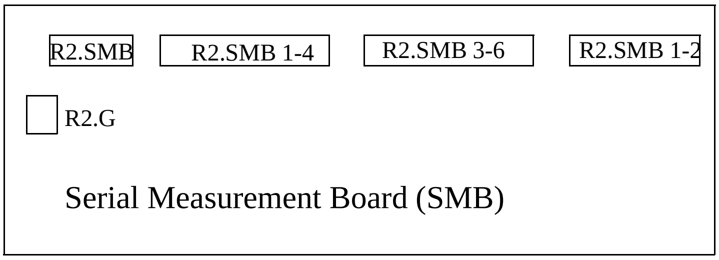
Resolver, connector on robot cabinet wall (option: 386 - External Axes Measurement Board, mounted inside robot cabinet)

XS27, Measurement System 2, board 1

	Node 1	Node 2	Node 3	Node 4	Node 5	Node 6
EXC1	A1	A3	A5			
0 V EXC1	A2	A4	A6			
EXC2				A8	A10	A12
0 V EXC2				A9	A11	A13
X	B1	B3	B5	B8	B10	B12
Y	C1	C3	C5	C8	C10	C12
0V X	B2	B4	B6	B9	B11	B13
0V Y	C2	C4	C6	C9	C11	C13

Resolver, connectors on Measurement Board DSQC 313

Contact/ point	R2.G	R2.SMB D-Sub 9 pin	R2.SMB 1-2 D-Sub 15 socket	R2.SMB 1-4 D-Sub 25 pin	R2.SMB 3-6 D-Sub 25 socket
1	+BAT	GND	GND	GND	GND
2	0V BAT	BATLD	0V EXC1	X1	X4
3		0V	0V EXC1	Y1	Y4
4		SDO-N	Y2	X2	X5
5		SDI-N	X2	Y2	Y5
6		+BATSUP	Y1	0V EXC1	0V EXC2
7		+24V	X1	0V EXC1	0V EXC2
8		SDO	-	0V EXC1	0V EXC2
9		SDI	EXC1	X3	X6
10			EXC1	Y3	Y6
11			0V Y2	X4	X3
12			0V X2	Y4	Y3
13			0V Y1	0V EXC2	0V EXC1
14			0V X1	0V X1	0V X4
15				0V Y1	0V Y4
16				0V X2	0V X5
17				0V Y2	0V Y5
18				EXC1	EXC2
19				EXC1	EXC2
20				EXC1	EXC2
21				0V X3	0V X6
22				0V Y3	0V Y6
23				0V X4	0V X3
24				0V Y4	0V Y3
25				EXC2	EXC1



SDO	serial communication output		
SDI	serial communication input		
+BAT	battery +		
0V BAT	battery 0 V		
BATLD	not to be used		
BATSUP	not to be used	EXC1	excitation power to resolver 1,2,3
+24 V	24 V power	EXC2	excitation power to resolver 4,5,6
0 V	0 V power	X1	Input x-stator node 1

5.3.4 Drive System

There are two drive systems 1 and 2. Each system is connected to the CPU board via a serial link. The link also supplies low voltage logic power to the rectifier and drive modules.

Each drive system has its own transformer. For information on fuses, power contactors etc. see documentation for the separate enclosure.

The rectifier DSQC 358C has in addition to its rectifier section also a drive inverter for one external axis. This rectifier can be used in all S4C robot cabinets except for those robots needing the DSQC 345D rectifier.

For robots using two drive units, an extra drive unit can be placed in the S4C robot cabinet. This drive unit is connected to the Drive System 2 serial communication link, but use the Drive System 1 rectifier. This combined system is called Drive System 1.2 .

If drive unit with three drive inverters (nodes) are used, axes with measurement node 1, 2, 3 or 4, 5, 6 may not be connected to the same drive unit.

If the function “common drive” is to be used, a contactor unit for motor selection is required.

As an option it’s possible to use Atlas DMC of FBU. Those units are always connected to drive system 2 and measurement system 2. They CANNOT be combined with internal controlled drive units connected to drive system 2. Up to 6 external axis can be connected using DMC:s and/or FBU:s. In section 5.3.5 there is a complete list of template files for external controlled axes.

When designing the drive system following has to be checked:

- Max motor current, in order not to demagnetize the motor.
- Max/rated current from drive inverter.
- Max/rated current from drive unit (sum of all inverters on same drive unit)
- Max/rated current from dc-link
- Max/rated power for bleeder
- Max/rated power from transformer

Note: If the system contains axes with no stand by state (the axes will continue to be controlled while the brakes are activated for the robot), the max allowed power consumption of these axes are 0.5 kW.

Note:
For safety reasons, the power supply to the external motor must be switched off when the robot is in the MOTORS OFF mode.

Drive system configuration with one external axis at Drive System 1 in S4C robot cabinet and five to six axes at Drive System 2 installed in external cabinet.

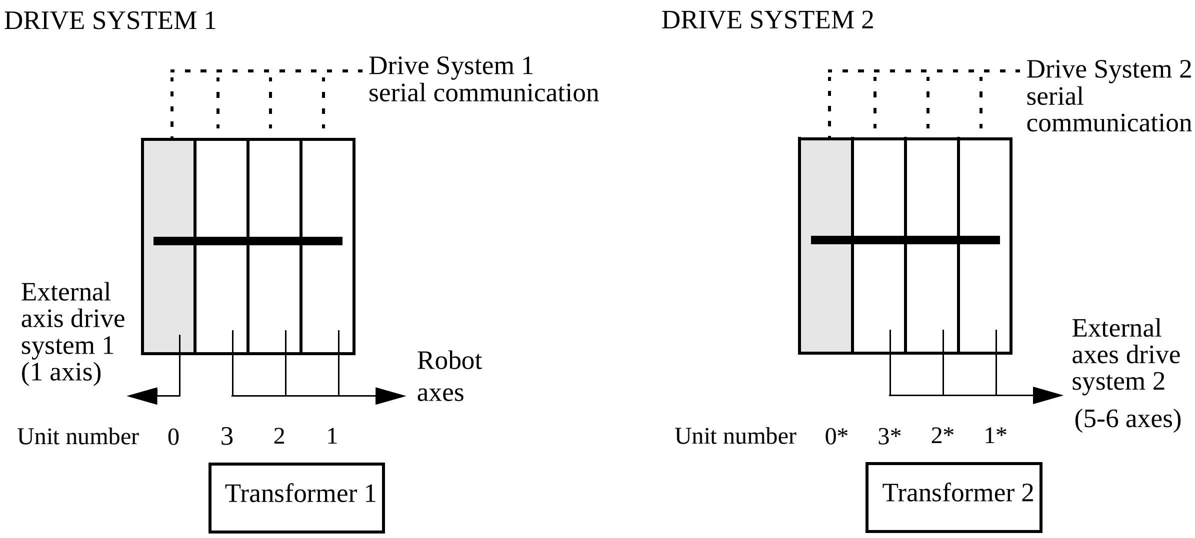


Figure 67 Drive systems with external cabinet.

Drive system configuration with one external axis at Drive System 1 and two or three axes at Drive system 2, all installed in the S4C robot cabinet.

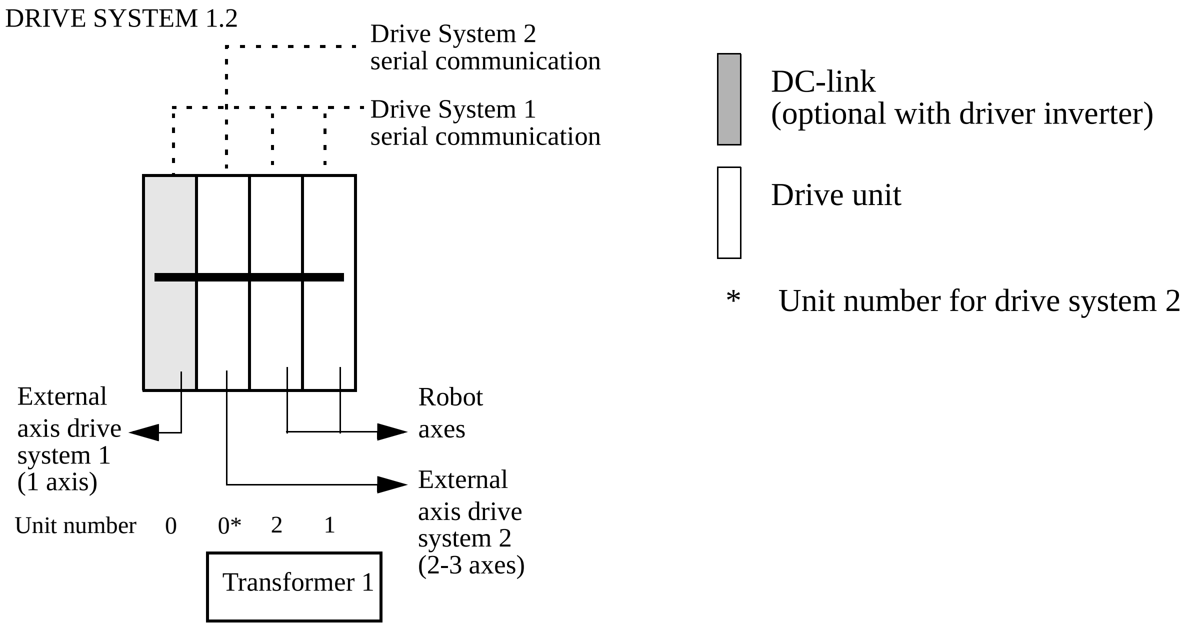


Figure 68 Drive system installed in the S4C cabinet.

Technical data Drive System

	Max current (A)	Rated current (A)	Max bleeder power (kW)	Rated bleeder power (kW)	Min voltage (V)
DSQC 345C / DC2 DSQC 358C / DC2T DSQC 358E / DC2C	80	14.6	15.3	0.9	275
DSQC 345D / DC3	70	16.7	15.3	0.9	370

Figure 69 Rectifier units.

Unit type	Node 1	Node 2	Node 3	Total unit
DSQC 346A	3.25/1.6 A	3.25/1.6 A	1.5/1.0 D	8.0/4.2
DSQC 346B	6.7/3.2 B	3.25/1.6 A	1.5/1.0 D	11.45/5.8
DSQC 346C	11.3/5.3 C	11.3/5.3 C	6.7/4.0 B	29.3/12.1
DSQC 346G	29.7/16.5 G	36.8/20.0 T		66.5/30.0
DSQC 358C		36.8/20.0 T		36.8/20.0
DSQC 358E		11.3/5.3 C		11.3/5.3 C

Figure 70 Drive units, max. current (A RMS)/average current (A RMS).

Pin	Node	Phase
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15	1 1 1 - - 3 - - 3 - - 3 2 2 2	W V U - - W - - V - - U W V U

Figure 71 Power connections, drive unit DSQC 346A, B, C   X2

Pin	Node	Phase
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15	1 1 1 1 1 1 2 2 2 2 2 2 2 2 2	U V W U V W U U U V V V W W W

Figure 72 Power connections, drive unit DSQC 246G   X2

Pin	,Node	Phase
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15	- - - - - - 2 2 2 2 2 2 2 2 2	- - - - - - U U U V V V W W W

Figure 73 Power connections, drive unit DSQC 358C, E   X2

Motor connection to drive unit, external connector

Motor current R-phase (U-phase), S-phase (V-phase) and T-phase (W-phase) respectively.

Technical data

Motor

Technical data	AC synchronous motor 3-phase, 4 or 6-pole ABB Flexible Automation can supply further information.

EXT PTC

This signal monitors the temperature of the motor. A high resistance or open circuit indicates that the temperature of the motor exceeds the rated level. If a temperature sensor is not used, the circuit must be strapped. If more than one motor is used, all PTC resistors are connected in series.

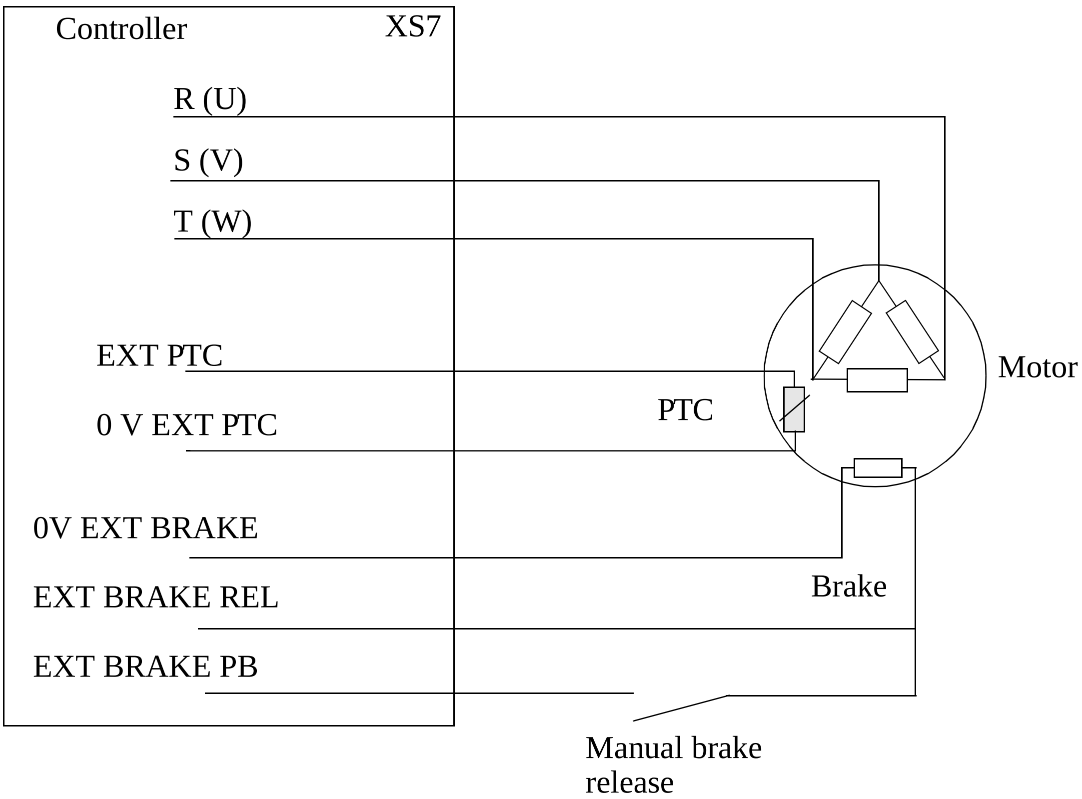


Figure 74 Connections of motor.

XS7, Connector on S4C robot cabinet wall (option: 391/392/394.)

Conn. Point	D	C	B	A
1	0V EXT PTC	M7 T	M7 S	M7 R
2	EXT PTC	M7 T	M7 S	M7 R
3	-	M7 T	M7 S	M7 R
4	PTC jumper 1	PTC jumper 2	LIM 2A	LIM 1A
5	PTC jumper 1	PTC jumper 2	LIM 2B	LIM 1B
6		M8 T	M8 S	M8 R
7		M8 T	M8 S	M8 R
8			BRAKE REL	BRAKE REL
9			0V BRAKE	BRAKE REL
10	-	0V BRAKE	0V BRAKE	BRAKE PB
11		M9 T	M9 S	M9 R
12		M9 T	M9 S	M9 R
13		M9 T	M9 S	M9 R
14				
15				
16				

Figure 75 Motor connections.

OPTION 391	Drive system	Drive Unit	Drive node	Node type
M7	1	0	2	T

OPTION 392	Drive system	Drive Unit	Drive node	Node type
M7	2	0	2	T
M8	2	0	1	G

OPTION 394	Drive system	Drive Unit	Drive node	Node type
M7	1	0	2	T
M8	2	0	1	G
M9	2	0	2	T

X7, Connector on external cabinet wall (options: 37x)

Conn. Point	D	C	B	A
1	0V EXT PTC	M7 T	M7 S	M7 R
2	EXT PTC	M7 T	M7 S	M7 R
3	-	M7 T	M7 S	M7 R
4	PTC jumper 1	PTC jumper 2	LIM 2A	LIM 1A
5	PTC jumper 1	PTC jumper 2	LIM 2B	LIM 1B
6	M10 R	M8 T	M8 S	M8 R
7	M10 R	M8 T	M8 S	M8 R
8	M10 S	M10 T	BRAKE REL	BRAKE REL
9	M10 S	M10 T	0V BRAKE	BRAKE REL
10	-	0V BRAKE	0V BRAKE	BRAKE PB
11	M12 R	M9 T	M9 S	M9 R
12	M12R	M9 T	M9 S	M9 R
13	M12 S	M9 T	M9 S	M9 R
14	M12 S	M11 T	M11 S	M11 R
15	M12 T	M11 T	M11 S	M11 R
16	M12 T	M11 T	M11 S	M11 R

OPTION 37M : axes M7-M8
OPTION 37N : axes M7-M10
OPTION 37O : axes M7-M12

	Drive system	Drive Unit	Drive node	Node type
M7	2	1	2	T
M8	2	1	1	G
M9	2	2	2	T
M10	2	2	1	G
M11	2	3	2	T
M12	2	3	1	G

OPTION 37P : axes M7-M9
OPTION 37Q : axes M7-M12

	Drive system	Drive Unit	Drive node	Node type
M7	2	1	1	C
M8	2	1	2	C
M9	2	1	3	B
M10	2	2	1	C
M11	2	2	2	C
M12	2	2	3	B

OPTION 37V : axes M7-M10
OPTION 37X : axes M7-M12

	Drive system	Drive Unit	Drive node	Node type
M7	2	1	1	C
M8	2	1	2	C
M9	2	2	2	T
M10	2	2	1	G
M11	2	3	2	T
M12	2	3	1	G

Incorrect definitions of the system parameters for brakes or external axes may cause damage to the robot or personal injury.

Note:
For safety reasons, the power supply to the external motor must be switched off when the robot is in the MOTORS OFF mode.

5.3.5 Configuration Files

In order to simplify installation of external axes a number of configuration files are delivered with the system. The configuration files are optimum designed concerning system behaviour and performance of the axes. When installing external axes it is important to design installations, so a combination of existent files can be used.

Four types of configuration files are delivered:

- Utility files for defining transformer and rectifier types in drive system 2.
- External axes files used for axes connected to a system with robot. File names MNxMyDz (**M**easurement **N**ode **x**, **M**easurement system **y**, **D**rive system **z**), see Figure 76.
- External controlled external axis. File names ENxM2D2 (**E**xternal **N**ode **x**, **M**easurement system **2**, **D**rive system **2**), see Figure 78.
- External axes files used in system without robot. File names ACxMyDz (**A**xis **C**ontrolled **x**, **M**easurement system **y**, **D**rive system **z**), see Figure 77.

For installing and change of parameter data, see the User’s Guide, section System Parameters, Topic: Manipulator.

In order to have the possibility to read and change most of the parameters from the teach pendent unit, the system must be booted in **service mode**.

Configuration file	Logical axis	Measuring system		Drive system		
		System*	Node*	System*	Unit position	Node
MN4M1D1	7	1	4(7)**	1	0	2
MN4M1D2	7	1	4(7)**	2	1	2
MN4M1D12	7	1	4(7)**	2	0	2
MN1M2D1	8	2	1	1	0	2
MN1M2D2	8	2	1	2	1	1
MN1M2D12	8	2	1	2	0	1
MN2M2D1	9	2	2	1	0	2
MN2M2D2	9	2	2	2	2	2
MN2M2D12	9	2	2	2	0	2
MN3M2D1	10	2	3	1	0	2
MN3M2D2	10	2	3	2	2	1
MN3M2D12	10	2	3	2	0	1
MN4M2D1	11	2	4	1	0	2
MN4M2D2	11	2	4	2	3	2
MN4M2D12	11	2	4	2	0	2
MN5M2D1	12	2	5	1	0	2
MN5M2D2	12	2	5	2	3	1
MN5M2D12	12	2	5	2	0	1
MN6M2D1	7	2	6	1	0	2
MN6M2D2	7	2	6	2	1	2
MN6M2D12	7	2	6	2	0	2

Figure 76 Configuration files with default data.

* Parameter value must not be changed.

** Is connected physically to node 4 but the logical value in the system parameters must be 7.

Logical axis is used as the axis number in the RAPID instruction and for the teach pendent. Normally the robot use axes 1-6 and the external axes 7-12. The user can change the logical axis number to fit the new application. Only axes with unique axis numbers may be active at the same time.

If drive units with three inverters are used, note the limitation described under drive system.

Configura-tion file	Logical axis	Measuring system		Drive system		
		System*	Node*	System*	Unit position	Node
AC1M1D1	7	1	1	1	1	2
AC2M1D1	8	1	2	1	2	2
AC3M1D1	9	1	3	1	3	2
AC4M1D1	10	1	4	1	2	1
AC5M1D1	11	1	5	1	3	1
AC6M1D1	12	1	6	1	1	1

Figure 77 Configuration files with default data.

Configura-tion file	Logical axis	Measuring system		Drive system		
		System*	Node*	Sys-tem*	Unit position	Node
EN1M2D2	8	2	1	2	0	1
EN2M2D2	9	2	2	2	1	1
EN3M2D2	10	2	3	2	2	1
EN4M2D2	11	2	4	2	3	1
EN5M2D2	12	2	5	2	4	1
EN6M2D2	13	12	6	2	5	1

Figure 78 Configuration files with default data.

Incorrect definitions of the system parameters for brakes or external axes may cause damage to the robot or personal injury.

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Maintenance

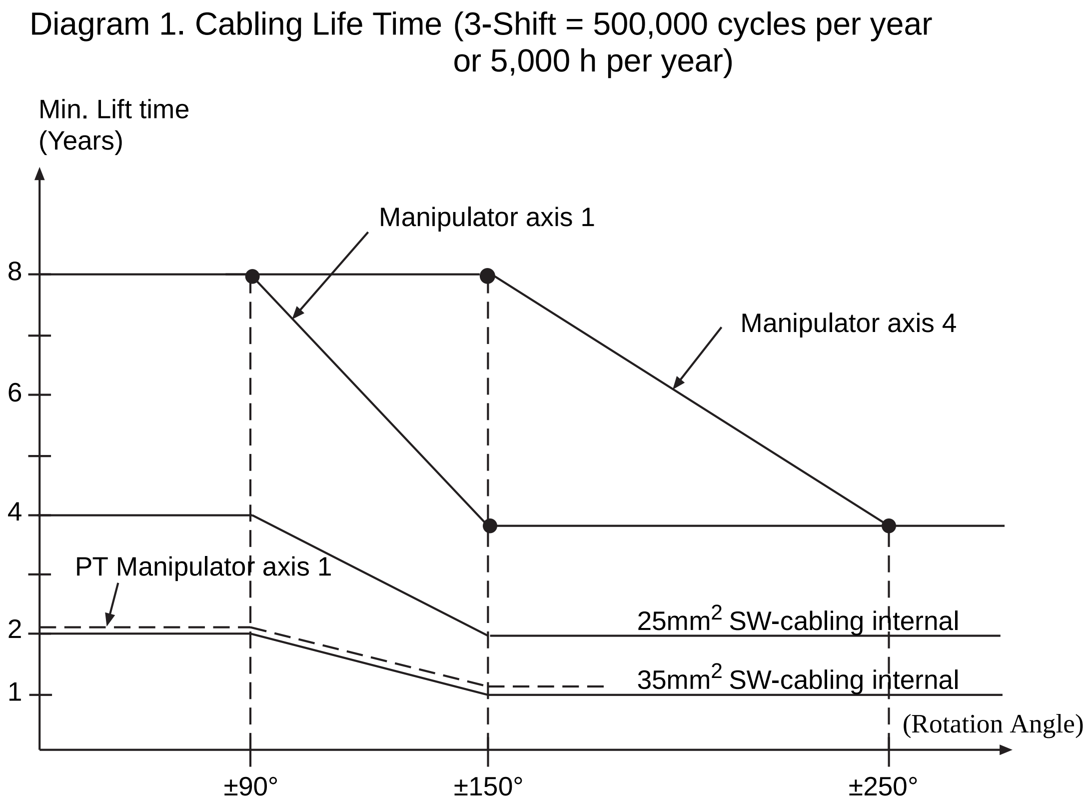
The robot is designed to be able to work under very demanding conditions with a minimum of maintenance. Nevertheless, certain routine checks and preventative maintenance must be carried out at specified periodic intervals, as shown in the table below.

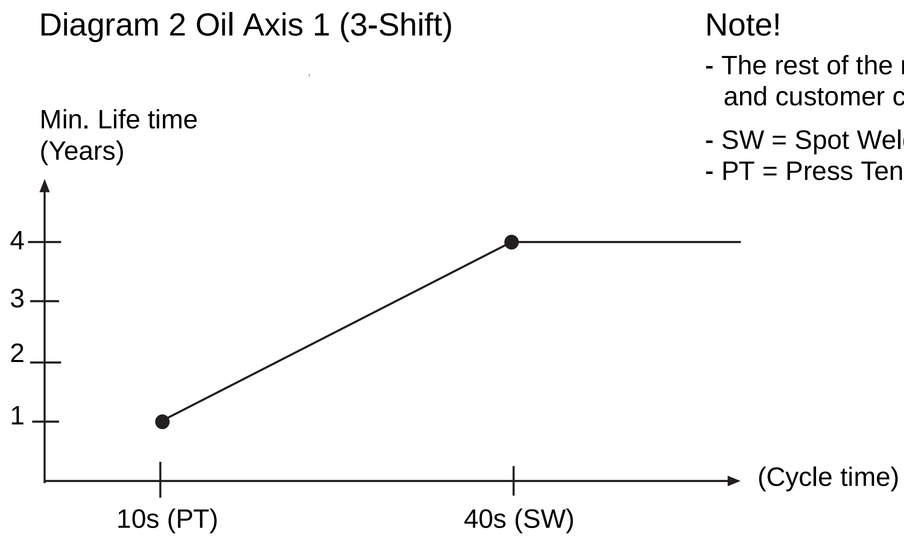
- The exterior of the robot should be cleaned as required. Use a vacuum cleaner or wipe it with a cloth. Compressed air and harsh solvents that can damage the sealing joints, bearings, lacquer or cabling, must not be used.
- The control system is completely encased, which means that the electronics are protected in a normal working environment. In very dusty environments, however, the interior of the cabinet should be inspected at regular intervals. Use a vacuum cleaner if necessary. Change filters in accordance with prescribed maintenance procedures.
- Check that the sealing joints and cable glands are really airtight so that dust and dirt are not sucked into the cabinet.

1 Maintenance Schedule

		Inspection		Maintenance intervals			
	Prescribed maintenance	**twice a year**	**once a year**	**4 000 h or 2 years**	**12 000 h or 3 years**	**5 years**	**20 000h or 4 years**
MANIPULATOR	Balancing unit axis 2 Bearings, inspection				X		
	Balancing unit axis 2 Bearings, greasing			X[1]	X		
	Balancing unit axis 2 Piston rod/Guide ring		X[2]				
	Cabling (see Figure 1 Diagram 1).		X[3]				
	Mechanical stop axis 1		X[4]				
	Gearbox 6 Grease changing				X[5]		
	Gearboxes 1-5 Oil changing (see Figure 1 Diagram 2).						X
	Oil level axes 1-5		X				
	Accumulator for measuring system Exchange				3 years[6]		
	Position Switch	X[1]	X				X[7]
CONTROL-LER	Filter for drive system cool-ing	X[8]		X			
	Memory back-up Battery changing					X[8]	

1. For foundry operation.
2. If the robot operation is utilized in adverse conditions (for example: particle-laden environments, such as spot welding, grinding, deflashing, etc.), perform preventive maintenance more frequently to ensure proper reliability of the robot system. See section 2.5.
3. Inspect all visible cabling. Change if damaged (valid for all cabling except cabling on axes 1 and 4).
4. Check the mechanical stop devices for deformation and damage. If the stop pin or the adjustable stop arm is bent, it must be replaced. See section 2.10.
5. For press-tending (refers to grease changing and operating life for gearbox axis 6) and heavy duty operation, axis 1 (option 5x is installed) see Figure 2 and Figure 3.
6. See section 2.11.
7. Not required in an ordinary industrial environment
8. See section 2.14.





Note!
- The rest of the manipulator and customer cabling = 8 years
- SW = Spot Welding
- PT = Press Tending

Figure 1

Axis 6

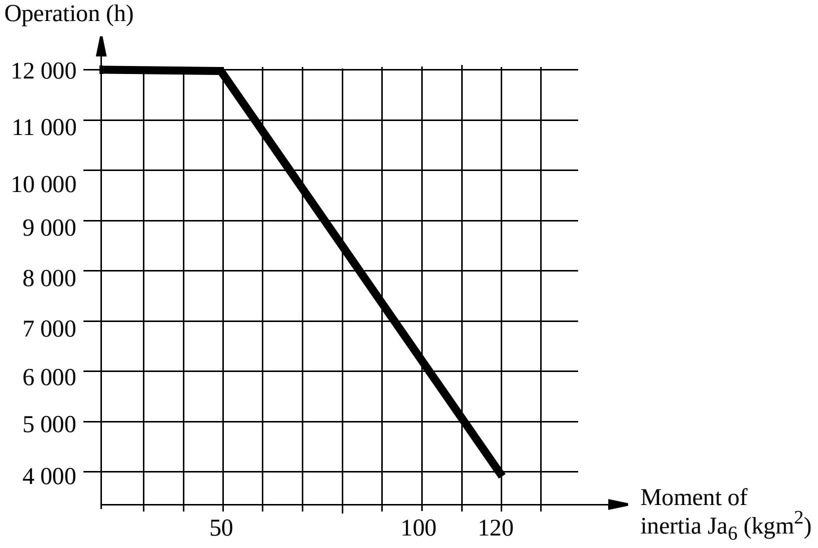


Figure 2 Recommended interval for changing grease on axis 6

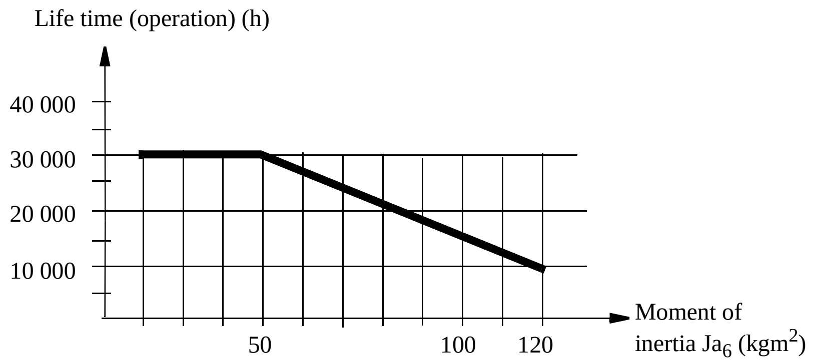


Figure 3 Approx. estimate of operating life of gearbox axis 6 as a function of the moment of inertia Ja_6. Ja_6 according to the Product Specification, chapter 3.

2 Instructions for Maintenance

2.1 General instructions for the manipulator

Check regularly:

- for any oil leaks. If a major oil leak is discovered, call for service personnel.
- for excessive play in gears. If play develops, call for service personnel.
- that the cabling between the control cabinet and robot is not damaged.

Check after a collision with external objects:

- that the upper and lower arms and the wrist is not damaged. If damage is discovered, call for service personnel.

Cleaning:

- Clean the robot exterior with a cloth when necessary. Do not use aggressive solvents which may damage paint or cabling.

2.2 Checking the oil and grease levels

Axis 6

The level in the gearbox is checked by adding new grease, until grease comes out through the special draining hole. See Chapter 2.9, Lubricating gearbox, axis 6.

Axes 1, 2, 3, 4 and 5

The level is checked by opening the oil plugs. See Chapter 2.3, Oil change gear box, axis 1, Chapter 2.6, Oil change gear box, axes 2 and 3, Chapter 2.7, Oil change gearbox, axis 4 and Chapter 2.8, Oil change gearbox, axis 5.

2.3 Oil change gear box, axis 1

- Remove the cover on the base (4), see Figure 4.
- The drain hose is placed under the cover (3).
- Remove the plug from the hose.
- Remove air plug (1).
- Drain off the old oil through the hose.
- Refit the plug to the hose.
- Remove the filling plug (2).
- Fill up with new oil until the oil level reaches the lower edge of the filling hole (2). See Volume below.
- Refit all plugs.

Volume:

- 11.5 litres. (3.35 US gallon)

Type of oil:

BP	ABB 1171 2016-604

Equivalents:

- BP	Energol GR-XP 320
- Castrol	Alpha SP 320
- Esso	Spartan EP 320
- Klüber	Lamora 320
- Mobil	Mobilgear 632
- Optimol	Optigear 5180
- Shell	Omala Oil 320
- Texaco	Meropa 320
- Statoil	Loadway EP

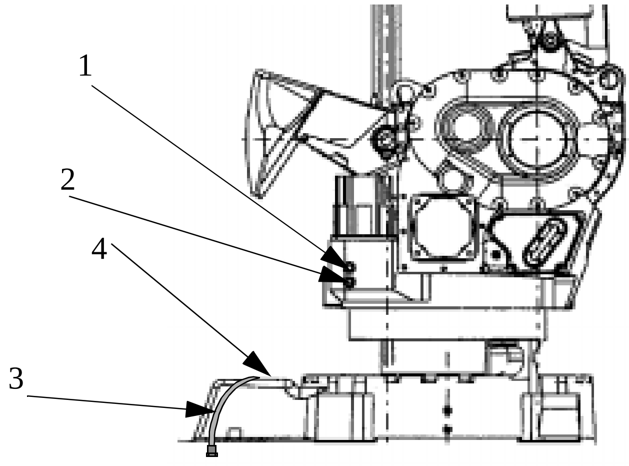


Figure 4 Lubricating gearbox, axis 1

2.4 Inspect and lubricate the bearings, balancing units axis 2

The bearings should be inspected and lubricated every 12,000 hours.

1. Move axis 2 to the sync position.

Make sure the shaft between the upper and lower arms does not rotate when unscrewing the KM nut.

2. Remove the KM- nuts (KM-10), the outer support washers and sealing rings.

Inspect

3. Fit the auxiliary shafts on the upper and lower axes (upper: aux. shaft 3HAB 5276-1, lower: aux. shaft 3HAB 5275-1). The shafts should be tightened to their bottom position.
4. Off-load the bearings using an M10x50 screw at the cylinder top.
5. Put out the cylinder so that the inner rings are fully exposed. Wipe the inner rings clean and check that there are no pressure marks or other similar deformations.
It is quite normal for the bearing races to have a darker colour than the surrounding material.
6. Inspect the support washers and sealing rings.
7. Push in the cylinder, make sure the inner support washers and sealing rings gets in correct position.
8. Remove the auxiliary shafts.

Lubrication

8. Fit the lubricating tool 3HAC 5222-1. The tool should be tightened to the bottom position using hand power only.
9. Grease through the nipple. Continue greasing until the grease exudes behind the inner sealing ring. Repeat procedure for the other bearings.
10. Remove the lubricating tool and clean the threads on the shaft ends free from grease.
11. Remount the outer sealing rings, apply some grease on the support washers, apply Loctite 243 on the KM nuts, not on the shafts, and tighten them to a torque of 50-60 Nm.
12. Check play (min. 0.1 mm) between support washer and bearingseat at both bearings.
13. N.B. Remove the M10x50 screw.

For more information about the procedure of replacing bearings, see Repairs.

Type of grease

- ABB art no. 1171 4013-301, quality 7 1401-301.
- ESSO Beacon EP 2.
- Shell Alvanina EP Grease.
- SKF Grease LGEP 2.
- BP Energrease LS-EP2.

Type of grease to Foundry robots

- - Shell Retinax MS

2.5 Lubricating piston rod, balancing unit axis 2

Move axis 2 to a position where the balancing units are in the horizontal position.

Wear

Check the guide ring for wear. If there is a risk of metallic contact between the piston rod and the end cover, the guide ring must be replaced. For replacement, see Repairs.

The article number of the guide ring is 3HAC 3476-1.

Lubrication

The piston rods should be lubricated. Clean the piston rod and apply new grease when necessary.

Type of grease

- Castrol Spheerol SX2 or equivalent.
- Shell Grease 1352 CA EP2.
- OK Super Grease L2.
- Statoil Uniway 2X2N.

2.6 Oil change gear box, axes 2 and 3

- Remove the air (1) and drain (3) plugs. See Figure 5.
- Drain off the old oil through the hole (3).
- Remove the filler plug(2).
- Refit the drain plug (3).
- Fill up with new oil until the oil level reaches the lower edge of the filling hole (2). See Volume below.
- Refit the filler and air plugs.

Volume:

- 12 litres. (3.50 US gallon)

Type of oil:

BP	ABB 1171 2016-604

Equivalents:

- BP	Energol GR-XP 320
- Castrol	Alpha SP 320
- Esso	Spartan EP 320
- Klüber	Lamora 320
- Mobil	Mobilgear 632
- Optimol	Optigear 5180
- Shell	Omala Oil 320
- Texaco	Meropa 320
- Statoil	Loadway EP

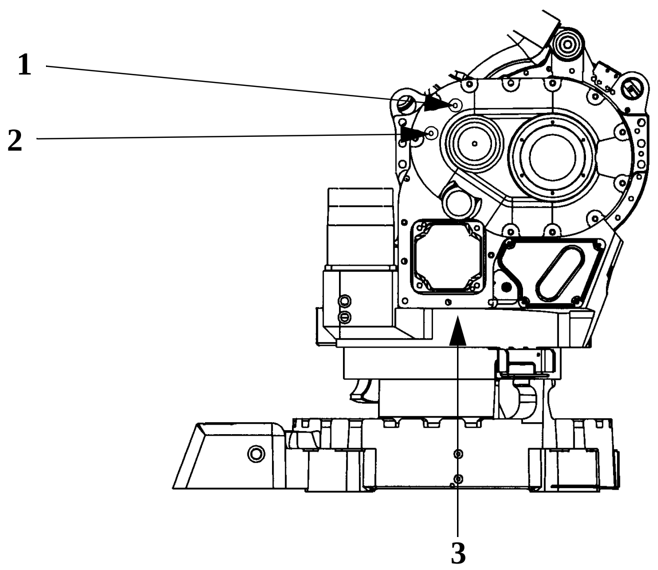


Figure 5 Drain holes, axes 2 and 3.

2.7 Oil change gearbox, axis 4

- Move the upper arm to the horizontal position.
- Remove the plugs (A) and (B).
- Drain off the old oil through the hole (A). See Figure 6.
- Clean the magnetic drain plug before refitting.
- Refit the drain plug (A).
- Fill up with new oil until the oil level reaches the lower edge of the filling hole (B).

Volume approx.:

- 6 litres (1.75 US gallon).

Correct oil level for axis 4 is to the lower edge of the upper oil level plug (B).

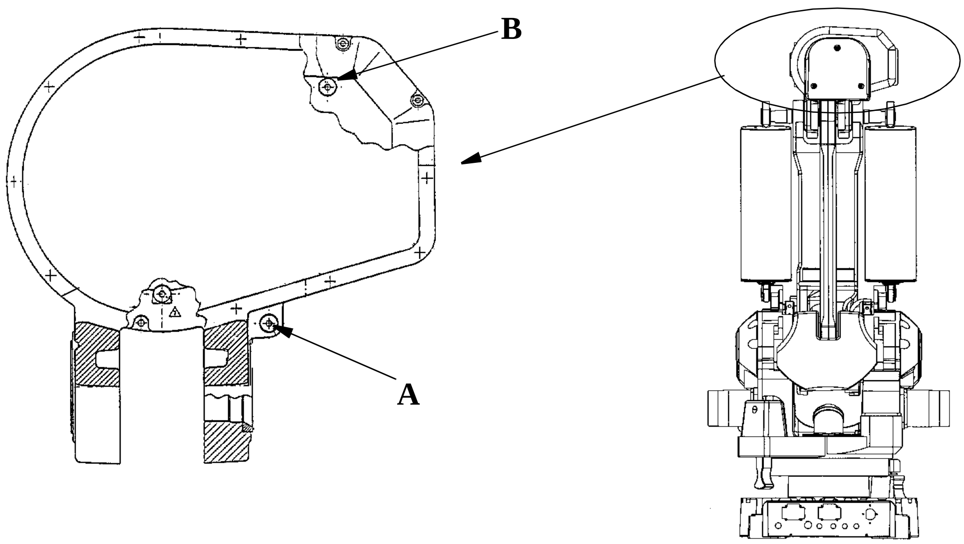


Figure 6 Drain hole axis 4

Type of oil:

- ABB 1171 2016-604

Equivalents:

- BP	Energol GR-XP 320
- Castrol	Alpha SP 320
- Esso	Spartan EP 320
- Klüber	Lamora 320
- Mobil	Mobilgear 632
- Optimol	Optigear 5180
- Shell	Omala Oil 320
- Texaco	Meropa 320
- Statoil	Loadway EP

2.8 Oil change gearbox, axis 5

- Move the upper arm to the horizontal position with axis 4 turned $+90^{o}$.
- Open the oil plug 1, and then oil plug 2 so that air can enter.
- Rotate axis 4 manually backwards and forwards to drain the oil, after first releasing the brake on axis 4.
- Clean the magnetic drain before refitting.
- Turn axis 4 through -90^{o} before filling oil. Fill oil through hole 2 until the oil is level with the lower edge of the filler hole.

Volume approx:

- 6 litres (1.75 US gallon).

Correct oil level for axis 5 is to the lower edge of the oil level plug.

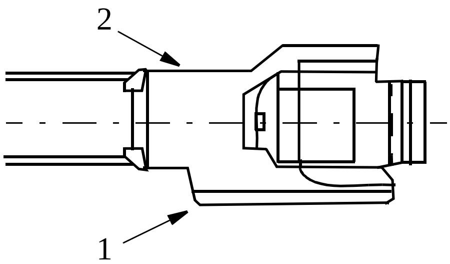


Figure 7 Oil change axis 5.

Type of oil:

- ABB 1171 2016-604

Equivalents:

- BP	Energol GR-XP 320
- Castrol	Alpha SP 320
- Esso	Spartan EP 320
- Klüber	Lamora 320
- Mobil	Mobilgear 632
- Optimol	Optigear 5180
- Shell	Omala Oil 320
- Texaco	Meropa 320
- Statoil	Loadway EP

2.9 Lubricating gearbox, axis 6

- Remove the plug from the drain hole (1). See Figure 8

WARNING! It is important that the drain plug is removed.

- Grease through the radial nipple of the turning gear (2).
- Rotate axis 6 while greasing.
- Continue to grease until new grease exudes from the drain hole (1). See Volume below.

Move axis 6 backwards and forwards a couple of times before the plugs are replaced, so that excess grease is pressed out. This is to prevent over-pressure in the gearbox, with risks for leakage.

Volume:

- 0.30 litres (0.085 US gallon).
- About 0.4 litres (0.11 US gallon) should be used when changing the grease.

Type of grease:

- Teijin Seiki   Molywhite   RE No. 00   ABB 3HAC 2331-1

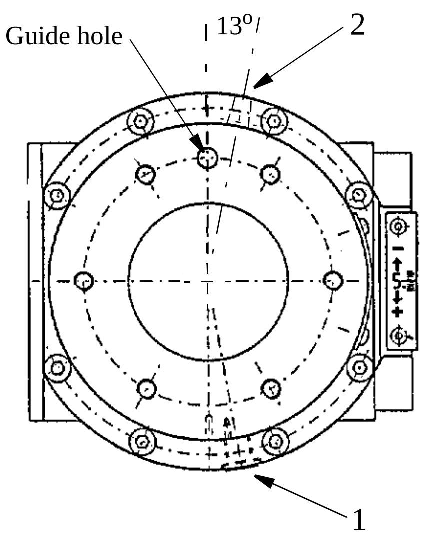


Figure 8 Greasing axis 6.

2.10 Checking mechanical stop, axis 1

Check regularly, as follows:

Fixed stop:

- that the stop is not bent.

Stop pin:

- that the stop pin can move in both directions
- that the stop pin is not bent.

Adjustable stops:

- that the stops are not bent.

Rubber dampers (axes 2 and 3).

- The rubber dampers on axes 2 and 3 will be deformed in the event of a mechanical stop and should be replaced by new ones.

WARNING!

1. If the fixed stop arm is bent, no attempt must be made to straightened it.

2. If the pin is bent, a collision between the swinging stop arm and the stop pin has probably occurred. A bent stop pin must always be replaced by a new one.

3. If any of the adjustable stops are bent, they must be replaced by new ones.

	Article number		
Stop pin	3HAC 3667-1		
Adjustable stop	3HAC 4656-1	15°	(Option)
	3HAC 4657-1	7.5°	(Option)

2.11 Changing the battery in the measuring system

The battery to be replaced is located under the cover (see Figure 9).

The robot is delivered with a lithium battery.

The battery must never be thrown away. It must always be handled as hazardous waste.

- Set the robot to the MOTORS OFF operating mode. (This means that it will not have to be coarse-calibrated after the change.)
- Loosen the battery terminals from the serial measuring board and remove the 4 screws that keeps the battery in place (see Figure 10).
- Install a new battery and connect the terminals to the serial measuring board.

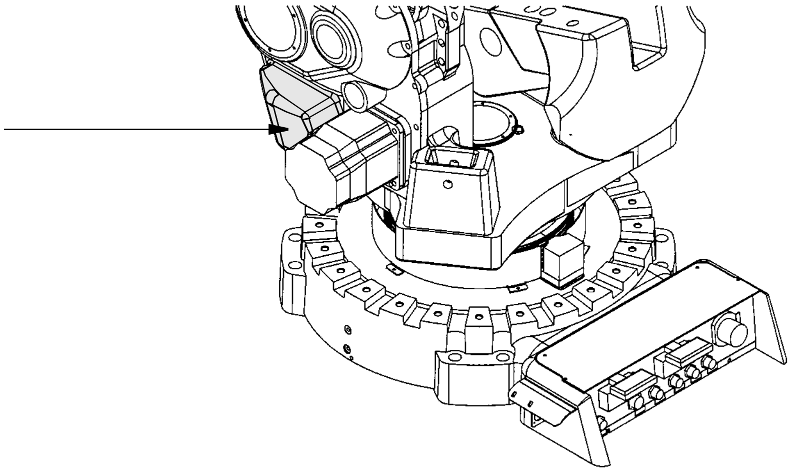


Figure 9 Battery location.

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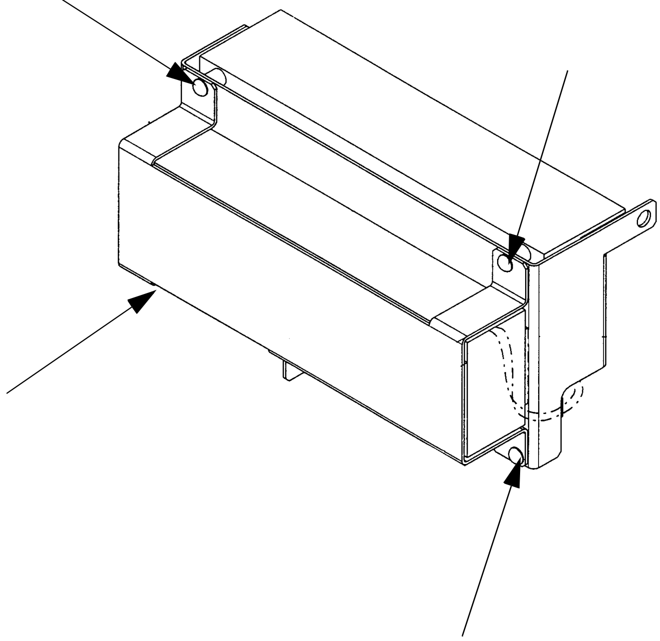


Figure 10 Fastening the battery.

The lithium battery needs no charging and for this reason there is a blocking diode which prevents charging from the serial measurement board.

Two types of lithium battery are available:

- a 3-cell battery, art.no. 3HAB 9999-1
- a 6-cell battery, art.no. 3HAB 9999-2

The service life of the lithium battery depends on how frequently the user switches off the power. The estimated max service life in years for the different types of lithium battery and the recommended exchange intervals are shown below:

User type:	**Exchange 3-cell:**	**Exchange 6-cell:**
1. Vacation (4 weeks) power off	every 5 years	every 5 years*
2. Weekend power off + user type 1	every 2 years	every 4 years
3. Nightly power off + user types 1 and 2	every year	every 2 years

* Because of material ageing the maximum service life is 5 years.

Voltage of batteries, measured at power off:

Lithium	nom. 10,8V

2.12 Changing filters/vacuum cleaning the drive-system cooling

The article number of the filter is 3HAB 8028-1.

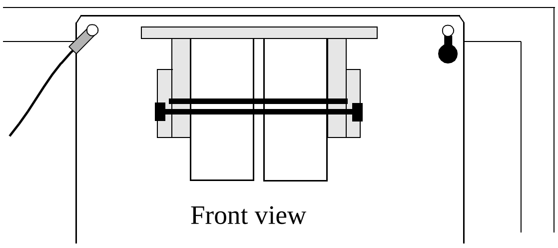
- Loosen the filter holder on the outside of the door by moving the holder upwards.
- Remove the old filter and install a new one (or clean the old one and re-install it).
- When cleaning, the rough surface (on the clean-air side) should be turned inwards. Clean the filter three or four times in 30-40° water with washing-up liquid or detergent. The filter must not be wrung out, but should be allowed to dry on a flat surface. Alternatively, the filter can be blown clean with compressed air from the clean-air side.
- If an air filter is not used, the entire cooling duct must be vacuum cleaned regularly.

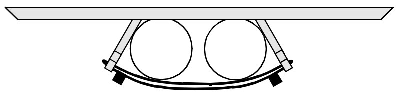
2.13 Changing the battery for memory back-up

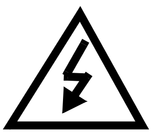
Type: Lithium Battery.

The article number of the battery is 3HAB 2038-1

The batteries (two) are located under the top cover to the right, at the top of the rear wall (see Figure 11).







Warning:

- Do not charge the batteries. An explosion could result or the cells could overheat.
- Do not open, puncture, crush, or otherwise mutilate the batteries. This could cause an explosion and/or expose toxic, corrosive, and inflammable liquids.
- Do not incinerate the batteries or expose them to high temperatures. Do not attempt to solder batteries. An explosion could result.
- Do not connect positive and negative terminals. Excessive heat could build up, causing severe burns.

Warning:

Do not incinerate or dispose of lithium batteries in general waste collection, as there is a risk of explosion. Batteries should be collected for disposal in a manner that prevents short circuitting, compacting, or destruction of case integrity and the hermetic seal.

Figure 11 The location of the batteries.

- Note from the teach pendant which of the two batteries has expired and needs replacement.
- Loosen the expired battery terminal from the backplane.

- Remove the battery by loosening the clasps.
- Insert the new battery and fasten the clasps.
- Connect the battery terminal to the backplane.
- If both batteries must be replaced, make sure that the power is kept on. Otherwise, all the memory contents will be erased. A completely new installation of Robot Ware and parameters is then necessary, see Installation and Commissioning.

2.14 RAM Battery lifetime

The maximum service life of the lithium battery is five years. The lifetime is influenced by the installed memory board type and by the length of time the system is without power.

The following table indicates the minimum time, in months, that memory will be held if the system is without power:

Memory board size	**First battery**	**Both batteries**
4 MB	6	12
6 MB	5	10
8 MB	6.5	13
16 MB	5	10

A battery test is performed on the following occasions:

1. System diagnostics (before software installation). Failing the test will result in one of the following messages on the display:

   - "Warning: Battery 1 or 2 < 3.3V" i.e. one of the batteries is empty.
   - "Error: Battery 1 and 2 < 3.3V" i.e. both batteries are empty.

2. Warm start. Failing test results in one of the following messages on the display:

   - 31501 Battery voltage too low on battery 1.
   - 31502 Battery voltage too low on battery 2.
   - 31503 Battery voltage too low on both batteries.

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Troubleshooting Tools

Generally speaking, troubleshooting should be carried out as follows:

- Read any error messages shown on the teach pendant display.
  What these messages mean is described in *System and Error Messages*.
- Check the LEDs on the units. See *Indication LEDs on the Various Units* page 14.
- Switch the power off and then on. When the robot is started up, a self diagnostic is run which detects any errors. The tests performed during the self diagnostic are described in the chapter *Diagnostics* page 3.
- Check the cables, etc., with the help of the circuit diagram.

1 Diagnostics

The control system is supplied with diagnostic software to facilitate troubleshooting and to reduce downtime. Any errors detected by the diagnostics are displayed in plain language with an code number on the display of the teach pendant.

All system and error messages are logged in a common log which contains the last 50 messages saved. This enables an “error audit trail” to be made which can be analysed. The log can be accessed from the Service window using the teach pendant during normal operation and can be used to read or delete the logs. All system and error messages available are listed in User’s Guide.

The diagnostic programs are stored in flash PROM on the robot computer board. The diagnostic programs are executed by the I/O computer.

The control system runs through various tests depending on the start up mode:

Cold Start -
Cold starts occur normally only when the control system is started the first time, or when any computer board has been replaced, or when the batteries have been disconnected.

First, the test programs are executed by the robot computer (I/O computer) and the main computer. These tests and the test results are displayed on the teach pendant. If the tests do not indicate any errors, a message will appear on the display, requesting you to insert a system diskette into the disk drive. If, however, the diagnostics detect an error, a message will appear on the display and the test will be stopped until the user hits a key on the teach pendant or on a terminal connected to the front connector on the robot computer.

Warm Start -
is the normal type of start up when the robot is powered on. During a warm start, only a subset of the test program is executed. These tests and the test results are displayed on the teach pendant.

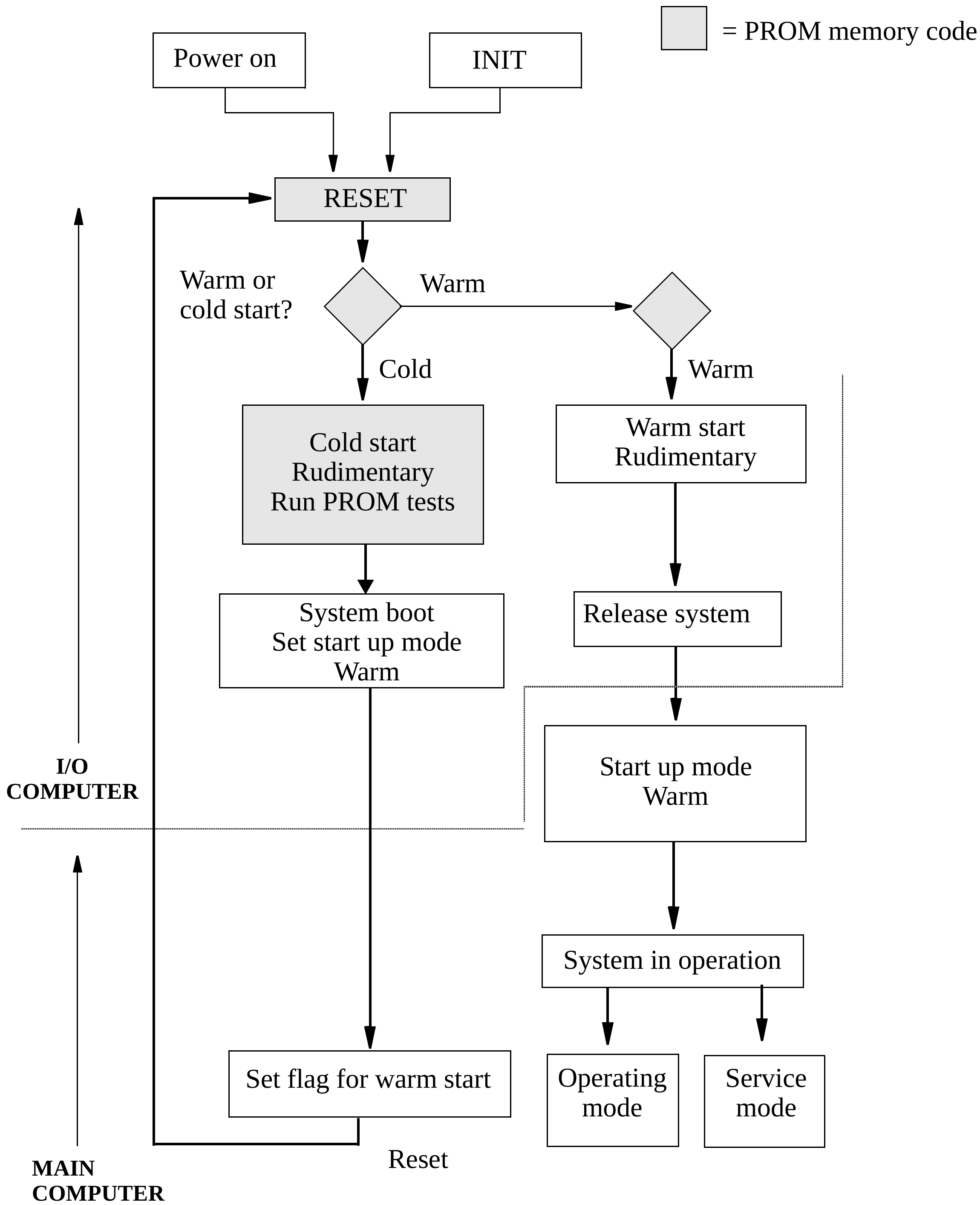
Another type of warm start, INIT, is carried out via a push button located on the backplane (see section 3). INIT is very similar to switching the power on. The tests that are run depend on whether or not the system is booted.

Monitor Mode 2 -
is a test condition in which a large number of tests can be run. A detailed description will be found in Chapter 1.2.

Under normal operating conditions, a number of test programs are run in the background. The operating system ensures that the tests can be run whenever there is a time slot.

The background tests are not seen in normal circumstances, but will give an indication when an error occurs.

Flow Chart of Diagnostic Software



1.1 Tests

Most of the internal robot tests are only run when the robot is cold started. All the tests can be run in Monitor Mode 2, as described in Chapter 1.2. Non destructive memory tests, checksum tests, etc., are only run when the robot is warm started.

Cold start tests in consecutive order.

IOC	=	Robot computer
AXC	=	Robot computer
MC	=	Main computer

At every “power on”, the IOC makes a destructive RWM test. If it fails, the IOC will flash the NS and MS front LEDs and stop the program running.

T1504: IOC Red LED off

T1005: IOC Memory test (RWM) Non Destructive

T1018: IOC Battery test

T1053: IOC IOC->AXC Access test

T1062: IOC IOC->AXC AM test

T1067: IOC IOC->AXC Memory test (RWM)

T1068: IOC IOC->AXC Memory test (RWM) R6 Global

T1069: IOC IOC->AXC Memory test (RWM) DSP

T1070: IOC Enable AXC->IOC Interrupts

T1061: IOC IOC->AXC Load AXC

T3001: AXC RWM test Dist.

T3002: AXC R6 Global RWM test

T3003: AXC DSP Double access RWM test

T3004: AXC DSP Data RWM test

T3020: AXC VME interrupt test

T3023: AXC Test channels output test

T1071: IOC Disable AXC->IOC Interrupts

T1046: IOC IOC->MC Access test

T1048: IOC IOC->MC AM test

T1050: IOC IOC->MC Memory test Destructive, Low win

T1506: IOC IOC->MC LED off

T1508: IOC IOC->ERWM LED off

T1512: IOC IOC->MC Load MC

T1509: IOC IOC->MC Release MC

T2002: MC Memory test (RWM) Destructive

T2010: MC Memory test (RWM) BM Destructive

T1510: IOC IOC->MC Reset MC

Warm start tests in consecutive order.

IOC = Robot computer

At every “power on”, the IOC makes a destructive RWM test. If it fails, the IOC will flash the NS and MS front LEDs and stop the program running.

T1504: IOC LED off

T1005: IOC Memory test (RWM) Non Destructive

T1018: IOC Battery test

1.2 Monitor Mode 2

When the system is in Monitor Mode 2, a large number of tests can be run.

These tests must be performed only by authorised service personnel. It should be noted that some of the tests will cause activity on customer connections and drive systems, which can result in damage, accidents etc. unless suitable precautionary measures are taken. It is advisable to disconnect all the connections involved during these tests.

To ensure that all memory addresses are resetted after testing shall the system be cold started.

The test mode Monitor mode 2 can be run from the teach pendant and/or a connected PC/terminal.

1.2.1 Entering the test mode from the teach pendant

1. Press the backplane TEST button, see section 3.

2. Keep the button depressed.

3. Push the INIT button, see section 3 (keep the TEST button pressed in).

4. Keep the TEST button depressed for at least 5 sec. (after releasing of the INIT button).

5. The display will show the following:

MONITOR MODE 2
if you proceed, system data will
be lost! Press any key to accept.

6. Then enter the password: **4433221**.

1.2.2 Console connected to a PC

A PC with terminal emulation (see PC manual). The PC shall be set up for 9600 baud, 8 bits, no parity, and shall be connected to the Console terminal on the front of the robot computer board.

Connection table: Console terminal on robot and main computer

Console		
Pin	**Signal**	**Description**
2	RXD	Serial receive data
3	TXD	Serial transmit data
5	GND	Signal ground (0V)

Start up:

1. Connect the PC.

2. Turn on the power to the robot.

Entering the test mode from a PC/terminal:

1. Press the backplane TEST button, see section 3.

2. Keep the button depressed.

3. Push the INIT button, see section 3 (keep the TEST button pressed in).

4. Keep the TEST button depressed for at least 5 sec. (after release of the INIT button).

5. The display will show the following:

MONITOR MODE 2
if you proceed, system data will
be lost! Press any key on the PC to accept.

6. Then enter the password: **ROBSERV.**

When the password has been entered (see above), a menu will be displayed, as shown below:

Welcome to Monitor Mode 2

1. Memory IO	(Tests the memory)
2. Serial IO	(Tests the serial channels)
3. Elementary IO	(Tests the IO units) ***Not yet implemented***
4. DSQC 3xx (IOC)	(Tests the IO computer)
5. DSQC 3xx (AXC)	(Tests the axes computer)
6. DSQC 3xx (MC, ERWM)	(Tests the main computer and external memory boards)
7. System tests (MISC)	(System-related tests)
8. Auxiliary	(Special tests) ***Not yet implemented***
9. Specific test	(Specific tests that can be run separately)

10. T1060 IOC System reset

Select test group and the test group menu will be displayed.

1. T9901 Memory IO

1. Up one level

2. FLOPPY
1. Up one level
2. T1039 IOC Floppy Format Test
3. T1040 IOC Floppy Write/Read Test

3. IOC RWM
1. Up one level
2. T1516 TIOC RWM size
3. T1005 IOC Memory test (RWM) Non destructive

4. AXC RWM
1. Up one level
2. T1067 IOC->AXC Memory test (RWM)
3. T1068 IOC->AXC Memory test (RWM) R6 Global
4. T1069 IOC->AXC Memory test (RWM) DSP
5. T3001 AXC RWM test Destr
6. T3002 AXC R6 Global RWM test
7. T3003 AXC DSP Double access RWM test
8. T3004 AXC DSP Data RWM test

5. MC/ERWM RWM
1. Up one level
2. T1517 MC/ERWM RWM size
3. T1047 IOC IOC->MC Memory test Destructive
4. T2002 MC Memory test (RWM) Destructive
5. T2010 MC Memory test (RWM) BM Destructive

6. PROM *(Not yet implemented)*

2. T9902 Serial I/O

1. Up one level

2. SIO 1 *(Not yet implemented)*

3. SIO 2
1. Up one level
2. T1029 IOC SIO2 RS422 loopback test
3. T1033 IOC SIO2 RS422 JUMPER test (Requires special hardware jumpers)

4. CONSOLE *(Not yet implemented)*

5. TPUNIT *(Not yet implemented)*

3. T9903 Elementary I/O (Not yet implemented)

4. T9911 DSQC 3xx (IOC)

1. Up one level

2. IOC CPU *(Not yet implemented)*

3. PROM *(Not yet implemented)*

4. RWM
1. Up one level
2. T1516 IOC RWM size
3. T1005 IOC Memory test (RWM) Non Destructive

5. RTC *(Not yet implemented)*

6. FDC
1. T9800 Up one level
2. T1039 IOC Floppy Format Test
3. T1040 IOC Floppy Write/Read Test

7. UART

1. T9800 Up one level
2. T1029 IOC SIO2 RS422 loopback test
3. T1013 IOC TPUNIT RS422 loopback test
4. T1033 IOC SIO2 RS422 JUMPER test (requires special hardware jumpers)
5. T1022 IOC TPUNIT RS422 JUMPER test (Requires special hardware jumpers and must be run from terminal)

8. DMA ***(Not yet implemented)***

9. VME ***(Not yet implemented)***

10. Miscellaneous

1. Up one level
2. T1018 IOC Battery test startup
3. T1060 IOC System Reset

11. LED

1. Up one level
2. T1503 IOC LED on
3. T1504 IOC LED off
4. T1518 IOC CAN LEDs sequence test

5. DSQC 3xx (AXC)

1. Up one level

2. AXC CPU ***(Not yet implemented)***

3. RWM

1. T9800 Up one level
2. T1067 IOC IOC->AXC Memory test (RWM)
3. T1068 IOC IOC->AXC Memory test (RWM) R6 Global
4. T1069 IOC IOC->AXC Memory test (RWM) DSP
5. T3001 AXC RWM test Dstr
6. T3002 AXC R6 Global RWM test
7. T3003 AXC DSP Double access RWM test
8. T3004 AXC DSP Data RWM test

4. VME

1. Up one level
2. T1053 IOC IOC->AXC Access test
3. T1062 IOC IOC->AXC AM test
4. T3020 AXC VME interrupt test

5. Miscellaneous
1. Up one level
2. T1072 IOC IOC->AXC Reset AXC
3. T1071 IOC Enable AXC->IOC Interrupts
4. T1061 IOC IOC->AXC Load AXC
5. T3018 AXC ASIC ID number
6. T3019 AXC Board ID number
7. T3023 AXC Test channels output test
8. T1071 IOC Disable AXC->IOC Interrupts

6. DSQC 3xx (MC, ERWM)

1. Up one level

2. MC CPU *(Not yet implemented)*

3. RWM
1. Up one level
2. T1517 MC/ERWM RWM size
3. T1047 IOC IOC->MC Memory test Destructive
4. T2002 MC Memory test (RWM) Destructive
5. T2010 MC Memory test (RWM) BM Destructive

4. LED
1. Up one level
2. T1505 IOC IOC->MC LED on
3. T1506 IOC IOC->MC LED off
4. T1507 IOC IOC->ERWM LED on
5. T1508 IOC IOC->ERWM LED off
6. T2501 MC LED on
7. T2502 MC LED off

5. Duart *(Not yet implemented)*

6. VME
1. Up one level
2. T1048 IOC IOC->MC AM test
3. T1046 IOC IOC->MC Access test

7. DMA *(Not yet implemented)*

8. Miscellanous
1. Up one level
2. T1512 LOAD MC DIAG
3. T1509 ENABLE MC
4. T1510 DISABLE (RESET) MC

7. System tests (Misc.)

1. Up one level

2. Battery
1. Up one level
2. T1018 IOC Battery test startup

3. IOC->MC
1. Up one level
2. T1046 IOC IOC->MC Access test
3. T1048 IOC IOC->MC AM test
4. T1505 IOC IOC->MC LED on
5. T1506 IOC IOC->MC LED off
6. T1507 IOC IOC->ERWM LED on
7. T1508 IOC IOC->ERWM LED off
8. T1512 LOAD MC DIAG
9. T1509 ENABLE MC
10. T1510 DISABLE (RESET) MC
11. T2501 MC LED on
12. T2502 MC LED off

4. IOC->AXC
1. T9800 Up one level
2. T1062 IOC IOC->AXC AM test
3. T1053 IOC IOC->AXC Access test
4. T1072 IOC IOC->AXC Reset AXC
5. T1070 IOC Enable AXC->IOC Interrupts
6. T1061 IOC IOC->AXC Load AXC
7. T3018 AXC ASIC ID number
8. T3019 AXC Board ID number
9. T3020 AXC VME interrupt test
10. T3023 AXC Test channels output test
11. T1071 IOC Disable AXC->IOC Interrupts

5. MC->AXC *(Not yet implemented)*

6. AXC->IOC *(Not yet implemented)*

7. VME *(Not yet implemented)*

8. RTC (Not yet implemented)

9. Reset password *(Re-boot required)*

10. Cold start *(Not yet implemented)*

8. Auxiliary (Not yet implemented)

9. Specific test

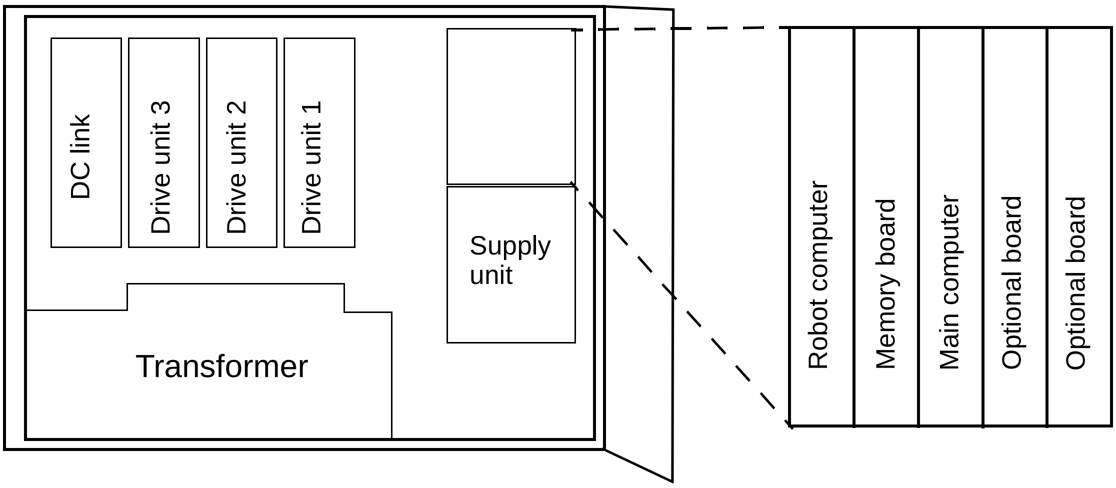
Specific test Txxxx
<Q> <q> or < > to quit
Enter test number Txxxx: T

10. IOC System reset (Not yet implemented)

All available tests have been defined in Chapter 1.1.

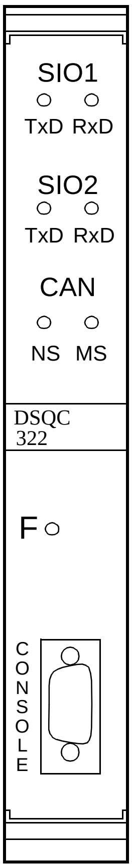
2 Indication LEDs on the Various Units

2.1 Location of units in the cabinet

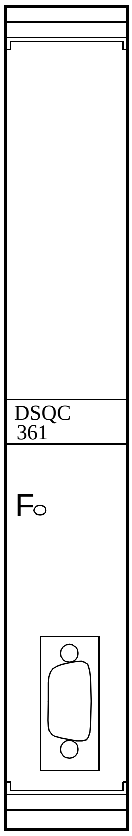


	IRB 1400	IRB 2400	IRB 4400	IRB 6400	IRB 640	IRB 840/A	IRB 340
Drive unit	*Axes*	*Axes*	*Axes*	*Axes*	*Axes*	*Axes*	*Axes*
1	1, 2, 4	1, 2, 4	1, 6	1, 6	1, 6	1(X), 6(C)	2, 1
2	3, 5, 6	3, 5, 6	2, 4	2, 4	2, 3	2(Y), 3(Z)	(4), 3
3			3, 5	3, 5			

2.2 Robot computer DSQC 363/373

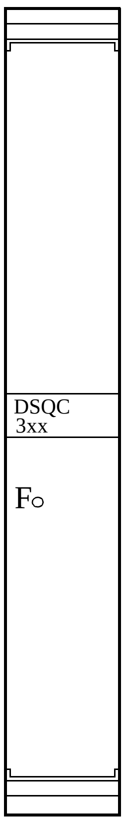


Designation	Colour	Description/Remedy
F	Red	Turns off when the board approves the initialisation.
TxD	Yellow	See section 2.14.
RxD	Yellow	See section 2.14.
NS	Green/red	See section 2.14.
MS	Green/red	See section 2.14.



2.3 Main computer DSQC 361

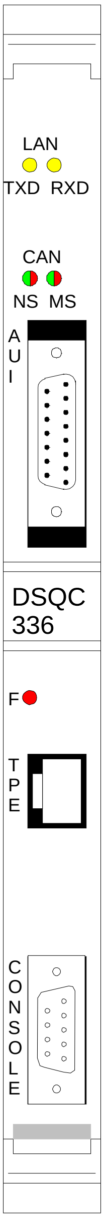
Designation	Colour	Description/Remedy
F	Red	Turns off when the board approves the initialisation.



2.4 Memory board DSQC 324/16Mb, 323/8Mb

Designation	Colour	Description/Remedy
F	Red	Turns off when the board approves the initialisation.

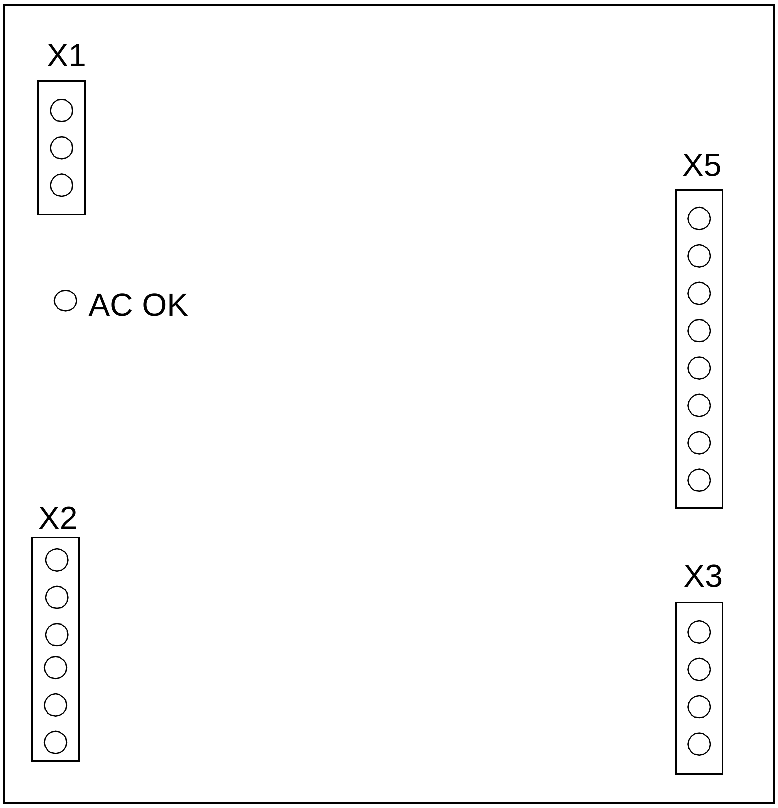
2.5 Ethernet DSQC 336



Designation	Colour	Description/Remedy
TxD	Yellow	Indicates data transmit activity. If no light when transmission is expected, check error messages and check also system boards in rack.
RxD	Yellow	Indicates data receive activity. If no light, check network and connections.
NS	Green/red	See section 2.14.
MS	Green/red	See section 2.14.
F	Red	Lit after reset. Thereafter controlled by the CPU. Light without message on display indicates a hardware fault preventing system from strating. By light and message on display, check message.

2.6 Power supply units

DSQC 334

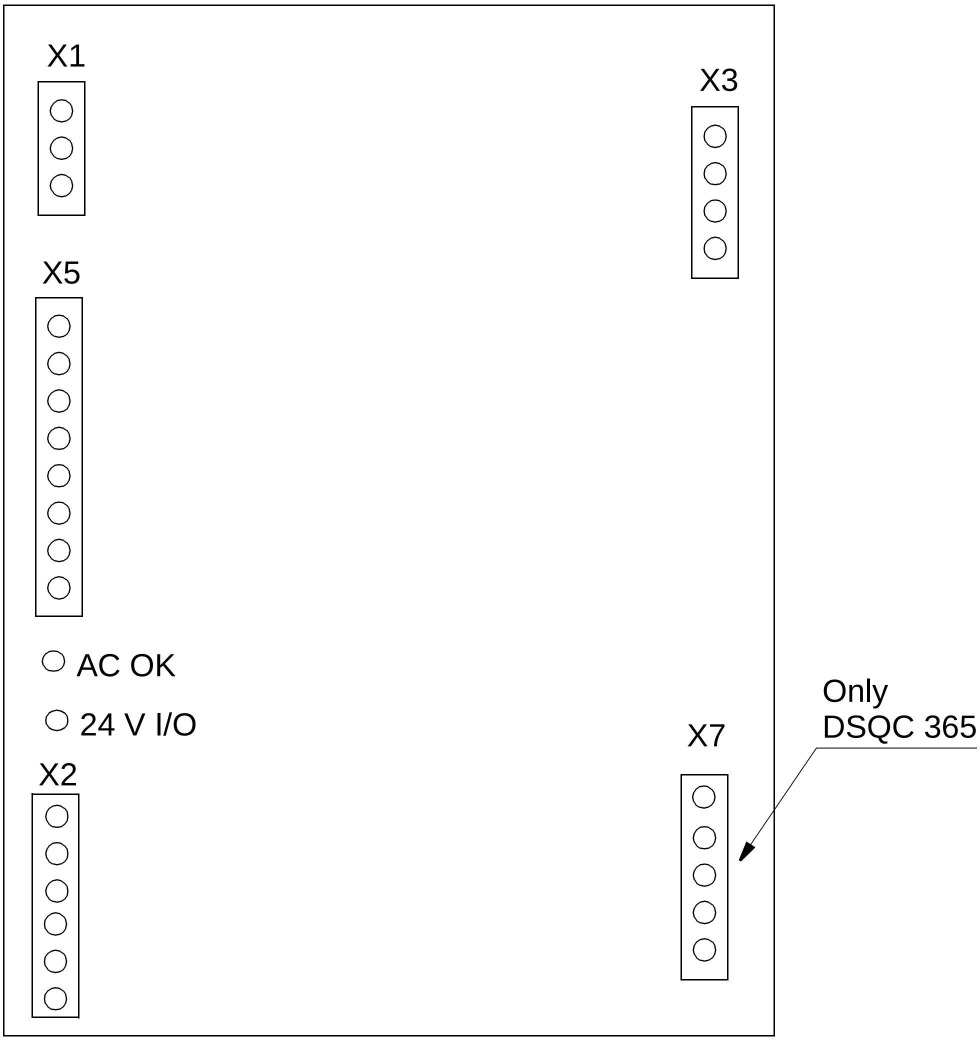


Designation	Colour	Description/Remedy
AC OK	Green	3 x 55V supply OK (start of ENABLE chain)

DSQC 374/365

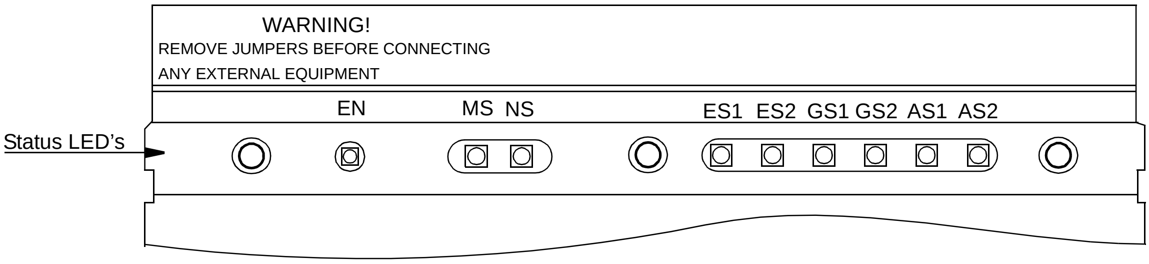
New “standard” power supply unit DSQC 374, introduced week 826 (M98 rev. 1)

New “extended” power supply unit DSQC 365 introduced week 840.



Designation	Colour	Description/Remedy
AC OK	Green	3 x 55V supply OK (start of ENABLE chain)
24 V I/O	Green	24 V I/O OK

2.7 Panel unit DSQC 331



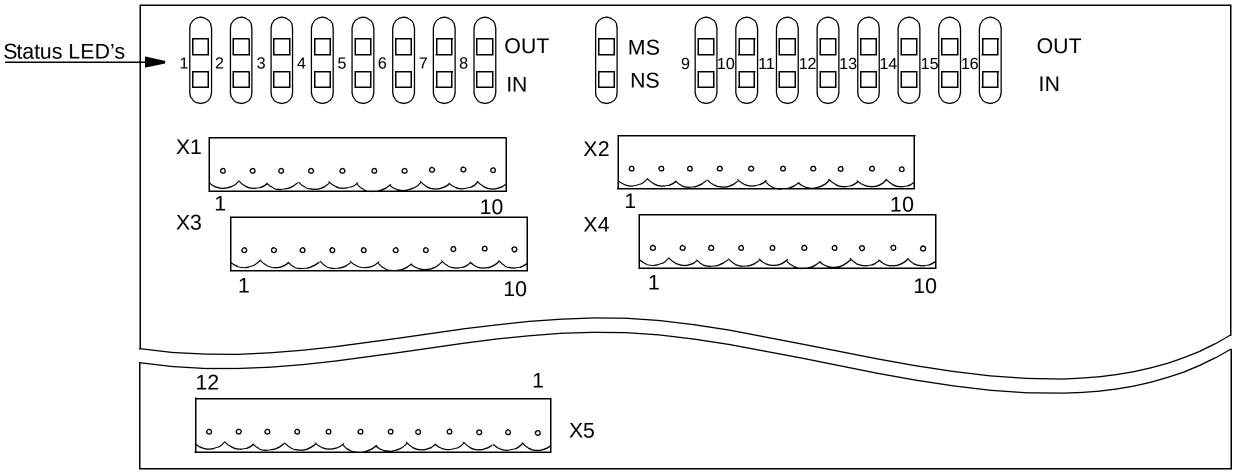
Designation	Colour	Description/Remedy
EN	Green	Enable signal from power supply and computers
MS/NS	Green/red	See section 2.14.
ES1 and 2	Yellow	Emergency stop chain 1 and 2 closed
GS1 and 2	Yellow	General stop switch chain 1 and 2 closed
AS1 and 2	Yellow	Auto stop switch chain 1 and 2 closed

2.8 Digital and Combi I/O units

All the I/O units have the same LED indications. The figure below shows a digital I/O unit, DSQC 328.

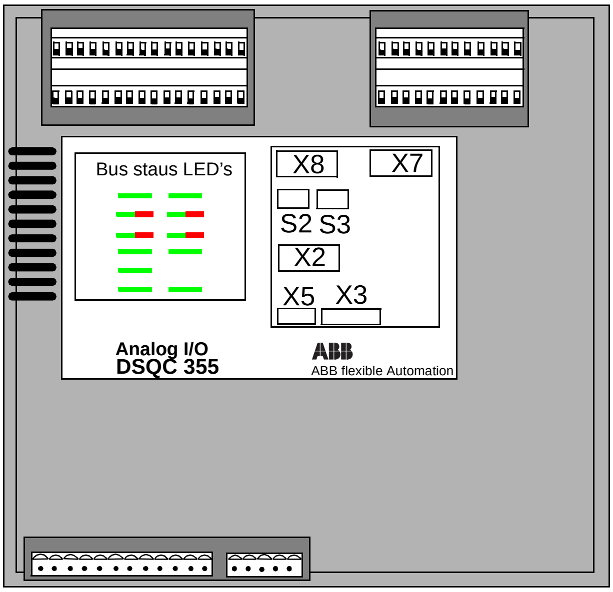
The description below is applicable for the following I/O units:

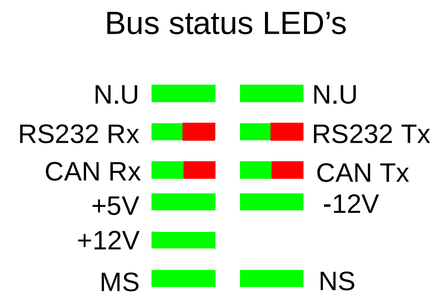
Digital I/O DSQC 328, Combi I/O DSQC 327,
Relay I/O DSQC 332 and 120 VAC I/O DSQC 320.



Designation	Colour	Description/Remedy
IN	Yellow	Lights at high signal on an input. The higher the applied voltage, the brighter the LED will shine. This means that even if the input voltage is just under the voltage level "1", the LED will glow dimly.
OUT	Yellow	Lights at high signal on an output. The higher the applied voltage, the brighter the LED will shine.
MS/NS	Green/red	See section 2.14.

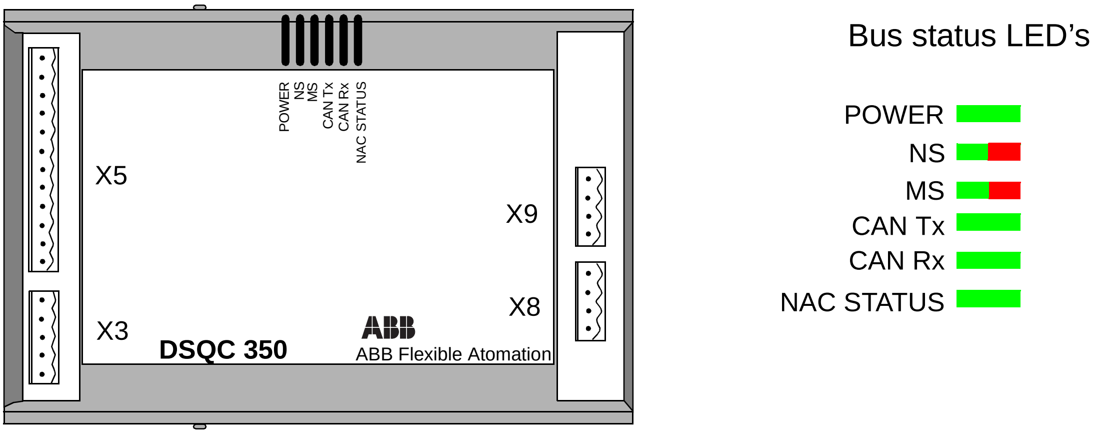
2.9 Analog I/O, DSQC 355





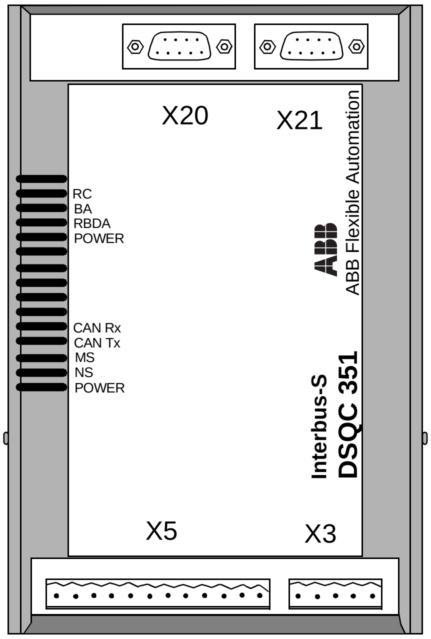
Designation	Colour	Description/Remedy
NS/MS	Green/red	See section 2.14.
RS232 Rx	Green	Indicates the state of the RS232 Rx line. LED is active when receiving data. If no light, check communication line and connections.
RS232 Tx	Green	Indicates the state of the RS232 Tx line. LED is active when tranceiving data. If no light when transmission is expected, check error messages and check also system boards in rack.
+5VDC / +12VDC /		
-12VDC	Green	Indicates that supply voltage is present and at correct level. Check that voltage is present on power unit. Check that power is present in power connector. If not, check cables and connectors. If power is applied to unit but unit does not work, replace the unit.

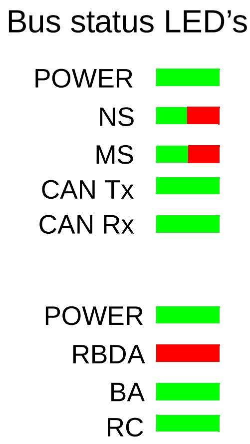
2.10 Remote I/O DSQC 350, Allen Bradley



Designation	Colour	Description/Remedy
POWER-24 VDC	Green	Indicates that a supply voltage is present, and has a level above 12 VDC. If no light, check that voltage is present on power unit. That power is present in power connector. If not, check cables and connectors. If power is applied to unit but unit does not work, replace unit.
NS/MS	Green/red	See section 2.14.
CAN Tx/CAN Rx	Yellow	See section 2.14.
NAC STATUS	Green	Steady green indicates RIO link in operation. If no light, check network, cables and connections. Check that PLC is operational. Flashing green, communication established, but INIT_COMPLETE bit not set in NA chip, or configuration or rack size etc. not matching configuration set in PLC. If LED keeps flashing continuously, check setup

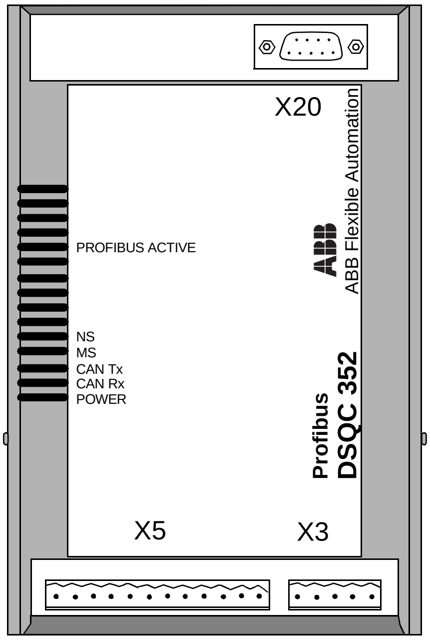
2.11 Interbus-S, slave DSQC 351

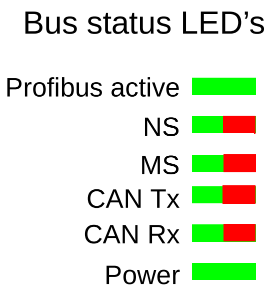




Designation	Colour	Description/Remedy
POWER-24 VDC	Green	Indicates that a supply voltage is present, and has a level above 12 VDC.
NS/MS	Green/red	See section 2.14.
CAN Tx/CAN Rx	Green/red	See section 2.14.
POWER- 5 VDC	Green	Lit when both 5 VDC supplies are within limits, and no reset is active.
RBDA	Red	Lit when this Interbus-S station is last in the Interbus-S network. If not as required, check parameter setup.
BA	Green	Lit when Interbus-S is active. If no light, check network, nodes and connections
RC	Green	Lit when Interbus-S communication runs without errors.

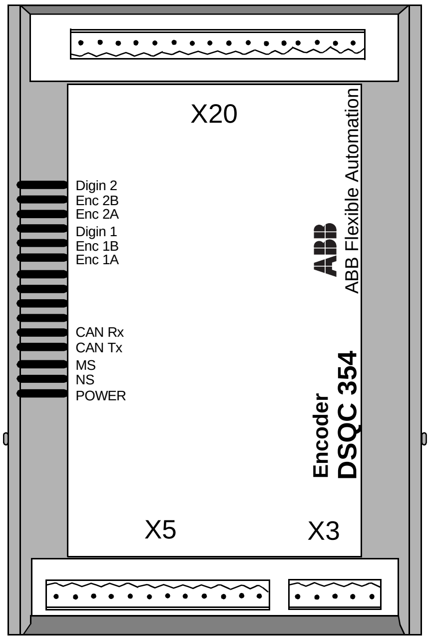
2.12 Profibus-DP, DSQC352

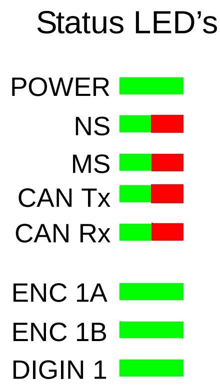




Designation	Colour	Description/Remedy
Profibus active	Green	Lit when the node is communicating with the master. If no light, check system messages in robot and in Profibus net.
NS/MS	Green/red	See section 2.14.
CAN Tx/CAN Rx	Green/red	See section 2.14.
POWER, 24 VDC	Green	Indicates that a supply voltage is present, and has a level above 12 VDC. If no light, check that voltage is present in power unit.Check that power is present in the power connector. If not, check cables and connectors. If power is available at the unit but the unit does not function, replace the unit

2.13 Encoder interface unit, DSQC354





Designation	Colour	Description/Remedy
POWER, 24 VDC	Green	Indicates that a supply voltage is present, and has a level above 12 VDC. If no light, check that voltage is present on power unit. That power is present in connector X20. If not, check cables and connectors.If power is applied to unit but unit does not work, replace unit.
NS/MS	Green/red	See section 2.14.
CAN Tx/CAN Rx	Yellow	See section 2.14.
ENC 1A/1B	Green	Indicates phase 1 and 2 from encoder. Flashes by each Encoder pulse. By frequencies higher than a few Hz, flashing can no longer be observed (light will appear weaker). If no light, faulty power supply for input circuit (internal or external). Defective input circuit on board. External wiring or connectors, short circuit or broken wire. Internal error in unit. Constant light indi cates constant high level on input and vice versa. No light in one LED indicates fault in one encoder phase.

DIGIN1	Green	Digital input. Lit when digital input is active. The input is used for external start signal/conveyor synchronization point. If no light, faulty limit switch, photocell etc. External wiring or connectors, short circuit or broken wire. Faulty power supply for input circuit (internal or external). Defective input circuit on board.

2.14 Status LEDs description

Each of the units connected to the CAN bus includes 2 or 4 LED indicators which indicate the condition (health) of the unit and the function of the network communication. These LEDs are:

All units

MS - Module status
NS - Network status

Some units:

CAN Tx - CAN network transmit
CAN Rx - CAN network receive

MS - Module status

This bicolour (green/red) LED provides device status. It indicates whether or not the device has power and is operating properly. The LED is controlled by software. The table below shows the different states of the MS LED.

Description	**Remedy / Source of fault**
Off No power applied to the device.	Check power supply.
Green Device is operating in a normal condition.	If no light, check other LED modes.
Flashing green Device needs commissioning due to configuration missing, incomplete or incorrect. The device may be in the Stand-by state.	Check system parameters. Check messages.
Flashing red Recoverable minor fault.	Check messages.
Red The device has an unrecoverable fault.	Device may need replacing.
Flashing red/green The device is running self test.	If flashing for more than a few seconds, check hardware.

NS - Network status

The bicolour (green/red) LED indicates the status of the communication link. The LED is controlled by software. The table below shows the different states of the NS LED.

Description	**Remedy / Source of fault**
Off Device has no power or is not on-line. The device has not completed the Dup_MAC_ID test yet.	Check status of MS LED. Check power to affected module.
Flashing green Device is on-line, but has no connections in the established state. The device has passed the Dup_MAC_ID test, is on-line, but has no established connections to other nodes. For a group 2 only device it means that the device is not allocated to a master. For a UCMM capable device it means that the device has no established connections.	Check that other nodes in network are operative. Check parameter to see if module has correct ID.
Green The device is on-line and has connection in the established state. For a group 2 only device it means that the device is allocated to a master. For a UCMM capable device it means that the device has one or more established connections.	If no light, check other LED modes.
Flashing red One or more I/O connections are in the Time-Out state.	Check system messages.
Red Failed communication device. The device has detected an error that has rendered it incapable of communicating on the network. (Duplicate MAC_ID, or Bus-off).	Check system messages and parameters.

Module- and network status LEDs at power-up

The system performs a test of the MS and NS LEDs during start-up. The purpose of this test is to check that all LEDs are functioning properly. The test runs as follows:

- - NS LED is switched Off.
- - MS LED is switched On green for approx. 0.25 seconds.
- - MS LED is switched On red for approx. 0.25 seconds.
- - MS LED is switched On green.
- - NS LED is switched On green for approx. 0.25 seconds.
- - NS LED is switched On red for approx. 0.25 seconds.
- - NS LED is switched On red.

If a device has other LEDs, each LED is tested in sequence.

CAN Tx - CAN network transmit

Description	**Remedy / Source of fault**
Green LED. Physically connected to the Can Tx line. Flashes when the CPU is receiving data on the CAN bus.	If no light when transmission is expected, check error messages. Check system boards in rack.

CAN Rx - CAN network receive

Description	**Remedy / Source of fault**
Green LED. Physically connected to the Can Rx line. Flashes when the CPU is transmitting data on the Can bus.	If no light, check network and connections.

3 Measuring Points

3.1 Back plane

The backplane contains a maintenance plug (X9) for signals that are hard to reach. Other signals are measured at their respective connection points, which can come in very handy when troubleshooting (see Figure 1).

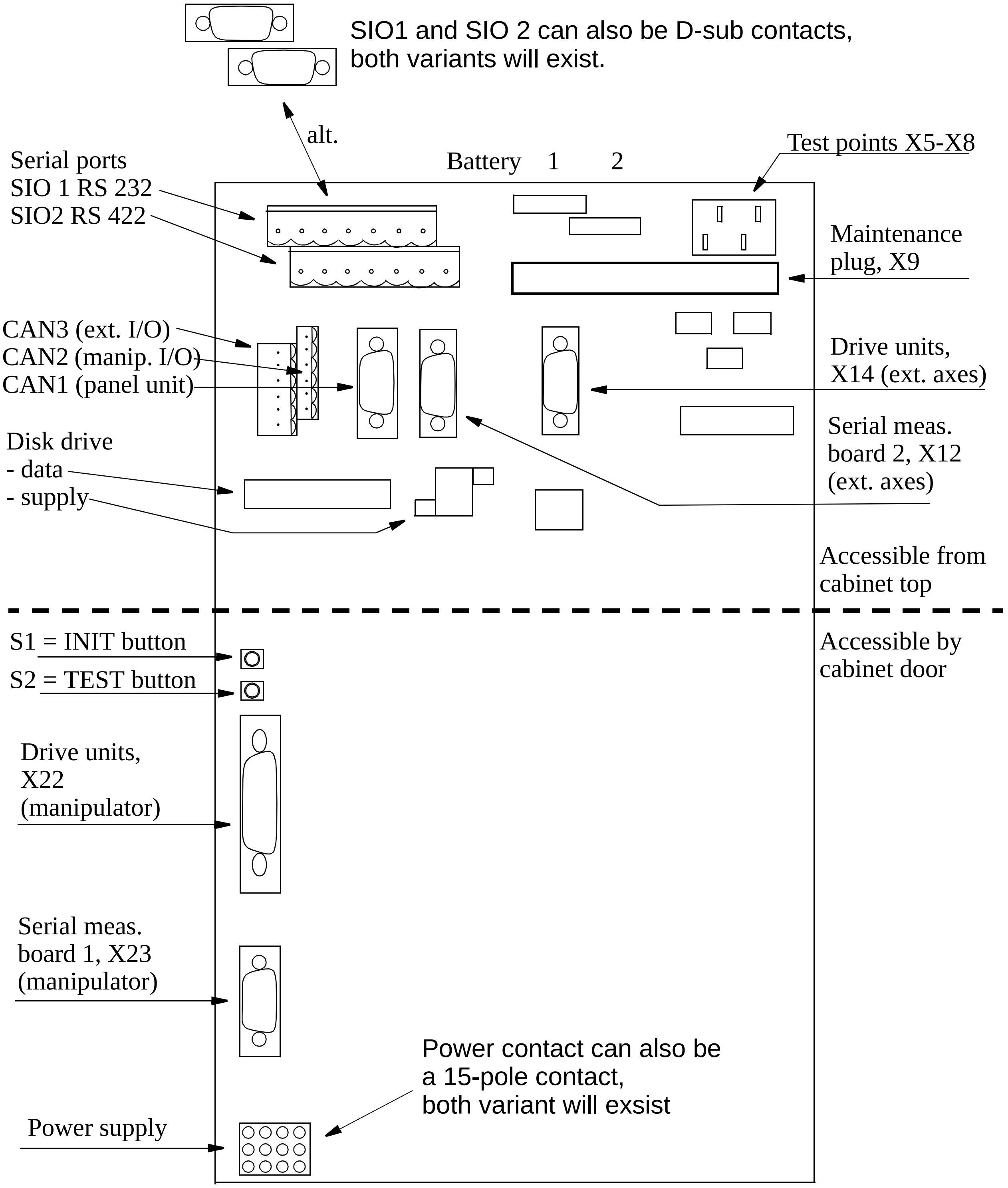


Figure 1 Back plane

3.2 Signal description, RS 232 and RS 422

RS 232

Signal	Explanation
TXD	Transmit Data
RXD	Receive Data
DSR	Data Set Ready
DTR	Data Terminal Ready
CTS	Clear To Send
RTS	Request To Send

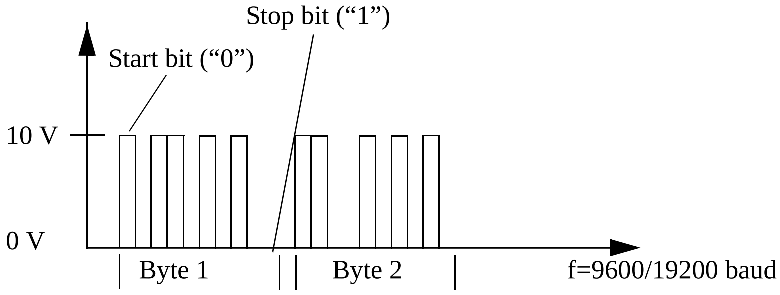


Figure 2 Signal description for RS 232.

The transmission pattern can be single or bursts of 10 bit words, with one start bit “0”, eight data bits (MSB first) and lastly one stop bit “1”.

RS 422

Signal	Explanation
TXD4/TXD4 N	Transmit Data in Full Duplex Mode
RXD4/RXD4 N	Receive Data in Full Duplex Mode
DATA4/DATA4 N	Data Signals in Half Duplex Mode
DCLK4/DCLK4 N	Data Transmission Clock

N.B! Only full duplex is supported.

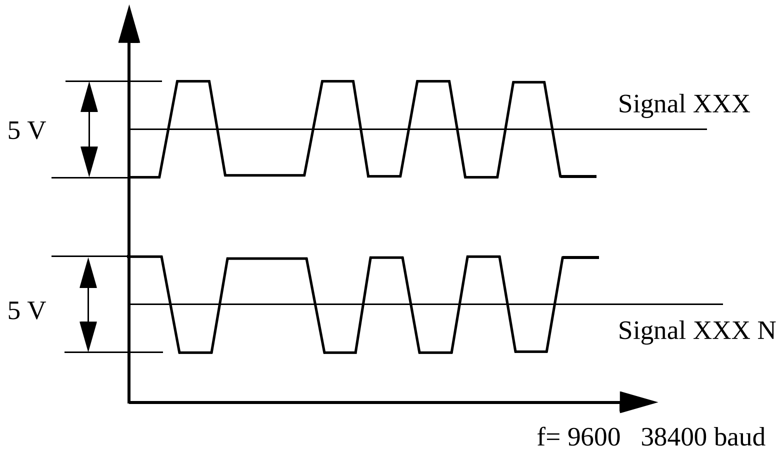


Figure 3 Signal description for RS 422, differential transmission.

When measuring the differential RS 422 signals, the oscilloscope should be set for AC testing. The data transmission has the same structure as RS 232, i.e. 1 start bit + 8 data bits + 1 stop bit, but the signals are differential. By looking at the “true” channel, it is possible to read the data.

If the types of signal as shown in the above diagram are obtained when measuring, this means that the drive circuits and lines are OK. If one or both of the signals do not move, it is likely that one or several line(s) or one or several drive circuit(s) is/are faulty.

3.3 X1 and X2 Serial links: SIO 1 and SIO 2

General serial interfaces: SIO 1 (X1) is an RS232 interface and SIO 2 (X2) is an RS422 interface. Explanation of signals see 3.2.

Screw terminals

X1	
Pin	**Signal**
1	TXD
2	RTS N
3	0V
4	RXD
5	CTS N
6	0V
7	DTR
8	DSR
9	0V
10	
11	
12	

X2	
Pin	**Signal**
1	TXD
2	TXD N
3	0V
4	RXD
5	RXD N
6	0V
7	DATA
8	DATA N
9	0V
10	DCLK
11	DCLK N
12	0V

D-sub connector

X1	
Pin	**Signal**
1	
2	RXD
3	TXD
4	DTR
5	0 V
6	DSR
7	RTS N
8	CTS N
9	

X2	
Pin	**Signal**
1	TXD
2	TXD N
3	RXD
4	RXD N
5	0 V
6	DATA
7	DATA N
8	DCLK
9	DCLK N

3.4 X9 Maintenance plug

3.4.1 Power supply

Supply voltages can be measured at the following points:

X9		
Pin	**Row A**	**Row C**
28	ACOK	DCOK
29	+ 5V_TST	0V
30	+ 15V_TST	0V
31	15V_TST	0V
32	+ 24V_TST	0V

There is a 10 kΩ resistor between each power supply line and the test terminal to prevent damage by a short circuit.

ACOK: Follows the AC power input without delay. High (= 5V) when power is OK.

DCOK: Follows the supply unit energy buffer. After power on, DCOK goes high (=5 V) when output voltages are stable.

3.4.2 X9 VBATT 1 and 2

Battery back-up for the computer memory and the real time clock.

Voltage of batteries 1 and 2; the voltage must be between 3.3 V and 3.9 V.

X9		
Pin	**Row A**	**Row C**
7	VBATT1	VBATT2
8	0V	0V

3.4.3 Drive system

The signal interface with the drive system. It complies with the EIA RS 422 standard, which means that signal transmission is differential. See 3.2 (Figure 3).

X9		
Pin	**A**	**C**
16	DRCI1	DRCI1 N
17	DRCO1	DRCO1 N
18	DRCI2	DRCI2 N
19	DRCO2	DRCO2 N
20	0V	

The DRCO signals travel from the robot computer to the drive units.
The DRCI signals enter the robot computer from the drive units.

DRCI1/DRCO1 signals are connected to the internal drive system (backplane connector X22, see 3.1).

DRCI2/DRCO2 are connected to external placed drive units (backplane connector X14, see 3.1).

3.4.4 Measuring system

The signal interface with the serial measuring system. It complies with the EIA RS 422 standard, which means that signal transmission is differential, see 3.2 (Figure 3).

X9		
Pin	**A**	**C**
20		0V
21	MRCI1	MRCI1 N
22	MRCO1	MRCO1 N
23	MRCI2	MRCI2 N
24	MRCO2	MRCO2 N

The MRCO signals travel from the robot computer to the measuring boards.
The MRCI signals enter the robot computer from the measuring boards.

MRCI1/MRCO1 signals are connected to the IRB axes (backplane connector X23, see 3.1).

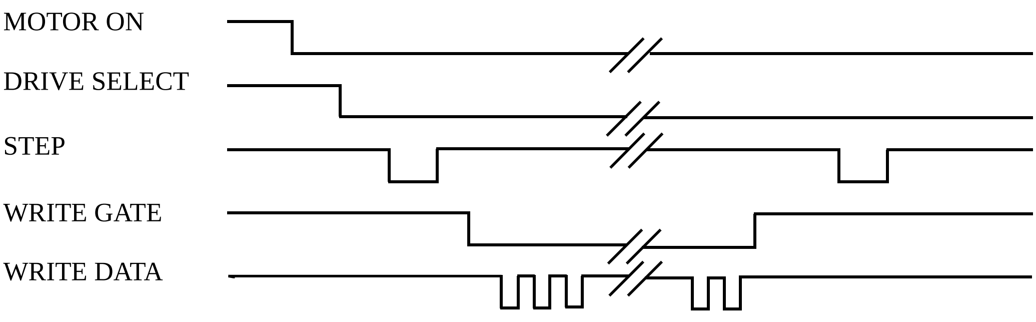
MRCI2/MRCO2 are used for external axes (backplane connector X12, see 3.1).

3.4.5 Disk drive

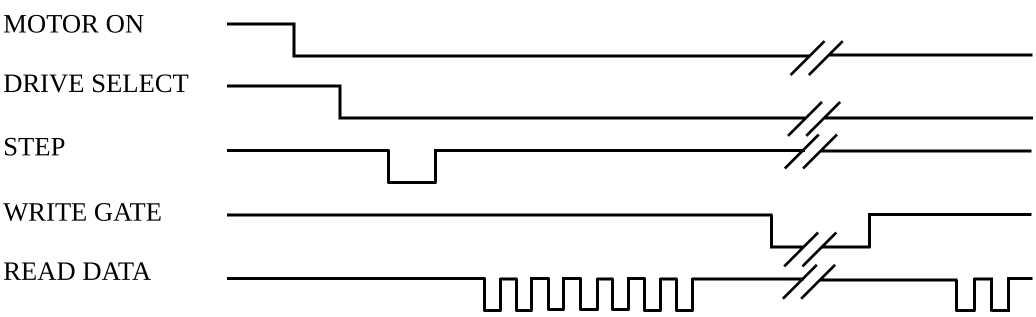
The signal interface with the disk drive; TTL levels “0” <=> 0V, “1” <=> +5V.

X9		
Pin	**A**	**Explanation**
9	RD N	Read Data, pulses. Data pulses when reading the diskette
10	WP N	Write Protect, static active low. Indicates whether or not the diskette is write protected.
11	DSKCHG N	Disk Change, static active low. Indicates whether or not there is a diskette in the unit.
12	WD N	Write Data, pulses. Data pulses when writing to the diskette.
13	SSO N	Side Select, static active low. Indicates which side of the diskette is active.
14	DIRC N	Direction in, static active low. Indicates that the heads are to move inwards.
15	0V	

X9		
Pin	**C**	**Explanation**
9	IP N	Index, pulses. One pulse per cycle, c. every 200 milliseconds.
10	TR00 N	Track 00, active low. Indicates that the heads are located at track 0 of the diskette.
11	MO N	Motor on, static low. Starts the motor in the selected unit.
12	WG N	Write Gate, pulses. Enables writing.
13	STEP N	Step, pulses. Steps the heads in the direction indicated by DIRC N.
14	HD N	High Density, static active low. Indicates that a 1.44 MB diskette is in the unit.
15	0V	



Write frequency



Read frequency

Figure 4 Diagram of write and read frequencies.

3.4.6 Teach pendant

The data transmission signal complies with the EIA RS 422 standard, see 3.2 (Figure 3).

X9		
Pin	**A**	**C**
6	DATA4=TP	DATA4-N=TP-N

3.4.7 CAN

X9		
Pin	**A**	**C**
25	CANRLY2 N	CANRLY3 N
26	CAN_H	CAN_L

CANRLY2 N and CANRLY3 N respectively:
0V when CAN 2 or CAN 3 is active (see Installation and Commissioning, section 3.17.3).

24V when CAN 2 and CAN 3 are disconnected (see Installation and Commissioning, section 3.17.3). In this case the backplane fixed termination resistor is connected in.

3.4.8 Safety

X9		
Pin	**A**	**C**
27	ENABLE9	SPEED

ENABLE 9:
5V when supply voltage is OK and the computers are OK (output from the robot computer to the panel unit; LED EN).

SPEED:
5V when one of the modes AUTO or MANUAL FULL SPEED is active (input to the robot computer from the panel unit).

CONTENTS

1 Fault tracing guide

Sometimes errors occur which neither refer to an error message nor can be remedied with the help of an error message.

To make a correct error diagnosis of these particular cases, you must be very experienced and have an in-depth knowledge of the control system. This section of the Product Manual is intended to provide support and guidance in any diagnostic work.

1.1 Starting Troubleshooting Work

Always start off by consulting a qualified operator and/or check any log books available to get some idea of what has happened, to note which error messages are displayed, which LEDs are lit, etc. If possible, look at the control system's error log; if there are any error messages there, it can be accessed from the Service menu. On the basis of this error information, you can start your analysis using the various tools, test programs, measuring points, etc., available.

Never start off by wildly replacing boards or units since this can result in new errors being introduced into the system.

When handling units and other electronic equipment in the controller, the wrist strap in the controller must be used to avoid ESD damage.

1.1.1 Intermittent errors

Unfortunately, intermittent errors sometimes occur and these can be difficult to remedy. This problem can occur anywhere in the robot and may be due to external interference, internal interference, loose connections, dry joints, heating problems, etc.

To identify the unit in which there is a fault, note and/or ask a qualified operator to note the status of all the LEDs, the messages on the teach pendant, the robot's behaviour, etc., each time that type of error occurs.
It may be necessary to run quite a number of test programs in order to pinpoint the error; these are run in loops, which should make the error occur more frequently.

If an intermittent error occurs periodically, check whether something in the environment in which the robot is working also changes periodically. For example, it may be caused by electrical interference from a large electric plant which only operates periodically. Intermittent errors can also be caused by considerable temperature changes in the workshop, which occur for different reasons.

Disturbances in the robot environment can affect cabling, if the cable screen connections are not intact or have been incorrectly connected.

1.1.2 Tools

Usually, the following tools are required when troubleshooting:

- Normal shop tools
- Multimeter
- Oscilloscope
- Recorder

1.2 Robot system

In this instance the robot system means the entire robot (controller + manipulator) and process equipment.

Errors can occur in the form of several different errors where it is difficult to localise one particular error, i.e. where it is not possible to directly pinpoint the unit that caused the problem. For example, if the system cannot be cold-started, this may be due to several different errors (the wrong diskette, a computer fault, etc.).

1.3 Main computer DSQC 361 and memory board DSQC 323/324

The main computer, which is connected to the VME bus and the local bus of the memory board, looks after the higher-level administrative work in the control system. Under normal operating conditions, all diagnostic monitoring is controlled by the main computer. At start-up, irrespective of whether a cold or warm start is performed, the robot computer releases the main computer when the robot computer's diagnostics allows it and, following this, the main computer takes over the control of the system. The read and write memories of the main computer are battery-backed.

If the red LEDs on the main computer light up (or do not turn off at initialisation), either a critical system failure has occurred or the main computer board or memory board is faulty.

The memory board is an extension of the main computer memory.

The memory board has a LED, F, which is lit and turned off by the main computer.

If there is a memory error on one of these boards, an error code will be shown on the display, T1047 or T2010. These error codes also include a field called the At address, which in turn contains an hexadecimal code that indicates on which board the erroneous memory circuit is located.

When the error is in the *main computer*, the hexadecimal code is in the following range:

0 X 000000 - 0 X 7FFFFF

When the error is in the *memory board*, the code is above 0 X 800 000.

1.4 Robot computer DSQC 363

The robot computer, which controls the system's I/O, axis control, serial communication and teach pendant communication, is the first unit to start after a cold or warm start. The red LED on the front of the board goes off immediately when the system is reset and goes on again if an error is detected in the tests. As mentioned above, the robot computer releases the main computer when the preliminary diagnostics have given the go ahead-signal.

The read and write memories of the robot computer are battery-backed.

If the system does not start at all, and the LED on the robot computer goes on, the error is probably in the robot computer.

1.5 Panel unit DSQC 331

The DSQC 331 Panel unit controls and monitors the dual operation chain. Its status is also indicated by LEDs at the upper part of the unit.

Over temperature of the motors is monitored by PTC inputs to the board.

LED indications for DSQC 331

Marking	Colour	Meaning
EN	Green	Indicates "go ahead" from the control system
MS NS ES 1 and 2 GS 1 and 2 AS 1 and 2	Green/red Green/red Yellow Yellow Yellow	Module status, normally green, see also section 1.6 Network status, normally green, see also section 1.6 EMERGENCY STOP, chain 1 and 2 closed GENERAL STOP switch, chain 1 and 2 closed AUTO STOP switch, chain 1 and 2 closed

The LEDs are very useful when trying to locate errors in the operation chain. Unlit LEDs indicate the whereabouts of an error in the operation chain, making the error easy to locate in the system circuit diagram.

1.5.1 Status of the Panel unit, inputs and outputs, displayed on the teach pendant

- Select the I/O window.
- Call up the *Units* list by choosing **View**.
- Select the **Safety** unit.

The location of the status signals are found in the circuit diagram, regarding Panel unit, where outputs are marked with and inputs with

See the table below.

Outputs DO

Name	**Meaning when “1” is displayed**
BRAKE	Energise brake contactor (i.e. release brakes) and turn on duty time counter
MONLMP	Turn on LED in motor-on push button
RUN CH1	Energise motor contactor chain 1
RUN CH2	Energise motor contactor chain 2
SOFT ASO	Choose delayed turn off of auto stop
SOFT ESO	Choose delayed turn off of emergency stop
SOFT GSO	Choose delayed turn off of general stop

Inputs DI

Name	Meaning when “1” is displayed
AS1	Auto stop chain 1 closed
AS2	Auto stop chain 2 closed
AUTO1	Mode selector chain 1; Auto operation
AUTO2	Mode selector chain 2; Auto operation
CH1	All switches in chain 1 closed
CH2	All switches in chain 2 closed
EN1	Enabling device chain 1 closed
EN2	Enabling device chain 2 closed
ES1	Emergency stop chain 1 closed
ES2	Emergency stop chain 2 closed
ENABLE	Enable from backplane
EXTCONT	External contactors closed
FAN OK	Fan in power supply running
GS1	General stop chain 1 closed
GS2	General stop chain 2 closed
K1	Motor contactor, chain 1, closed
K2	Motor contactor, chain 2, closed
LIM1	Limit switch chain 1 closed
LIM2	Limit switch chain 2 closed
MAN2	Mode selector chain 2; Manual operation
MANFS2	Mode selector chain 2; Manual full speed operation
MANORFS1	Mode selector chain 1; Manual or manual full speed operation
MON PB	Motor-On push button pressed
PTC	Over temperature in motors of manipulator
PTC Ext.	Over temperature in external device
SOFT ASI	Delayed turn off of auto stop (read back of digital output)
SOFT ESI	Delayed turn off of emergency stop (read back of digital output)
SOFT GSI	Delayed turn off of general stop (read back of digital output)
TRFOTMP	Over temperature in main transformer
24V panel	24V panel is higher than 22V

1.6 Distributed I/O

I/O units communicate with the I/O computer, located on the robot computer board, via the CAN bus. To activate the I/O units they must be defined in the system parameters.

The I/O channels can be read and activated from the I/O menu on the teach pendant.

In the event of an error in the I/O communication to and from the robot, check as follows:

1. Is I/O communication programmed in the current program?

2. On the unit in question, the MS (Module status) and NS (Network status) LEDs must be lit with a fixed green colour. See the table below regarding other conditions:

MS LED is:	**To indicate**	**Action**
Off	No power	Check 24 V CAN
Green	Normal condition	
Flashing green	Software configuration missing, standby state	Configure device
Flashing red/green	Device self testing	Wait for test to be completed
Flashing red	Minor fault (recoverable)	Restart device
Red	Unrecoverable fault	Replace device

NS LED is:	**To indicate**	**Action**
Off	Not powered/not on-line	
Flashing green	On-line, not connected	Wait for connection
Green	On-line, connections established	
Red	Critical link failure, incapable of communicating (duplicate MAC ID, or bus-off)	Change MAC ID and/or check CAN connection/cables

3. Check that the current I/O signal has the desired status using the I/O menu on the tech pendant display.

4. Check the I/O unit's LED for the current input or output. If the output LED is not lit, check that the 24 V I/O power supply is OK.

5. Check on all connectors and cabling from the I/O unit to the process connection.

1.7 Serial Communication

The most common causes of errors in serial communication are faulty cables (e.g. mixed-up send and receive signals) and transfer rates (baud rates), or data widths that are incorrectly set. If there is a problem, check the cables and the connected equipment before doing anything else.

The communication can be tested using the integral test-program, after strapping the input to the output. See chapter 9.

1.8 Drive System and Motors

The drive system, which consists of rectifier, drive unit and motor, is controlled by the axis computer, located on the robot computer board.

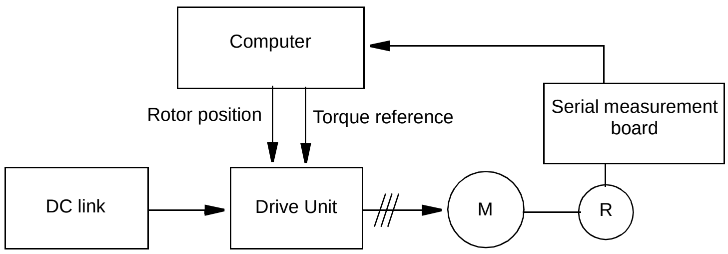


Figure 1 A schematic description of the drive system.

The drive system is equipped with internal error supervision. An error is sent on via the robot computer and can be read on the teach pendant display as an error message. An explanation of the available error messages can be found in the User’s Guide, System and error messages, section 3, error no. 39XXX.

If a drive unit or rectifier is faulty, the unit should be replaced. Internal troubleshooting cannot be performed in the operating environment.

1.9 Teach Pendant

The teach pendant communicates with the robot computer via a cable. This cable is also used for the +24 V supply and the dual operation chain.

If the display is not illuminated, try first adjusting the contrast, and if this does not help check the 24 V power supply.

Communication errors between the teach pendant and the I/O computer are indicated by an error message on the teach pendant.

For measuring points for the teach pendant communication signals, see chapter 9.

1.10 Measurement System

The measurement system comprises an axis computer, one or more serial measurement boards and resolvers. The serial measurement board is used to collect resolver data. The board is supplied from 24 V SYS via a fuse on the back plane. The board is located in the manipulator and is battery-backed. Communication with the axis computer takes place across a differential serial link (RS 485).

The measurement system contains information on the position of the axes and this information is continuously updated during operation. If the resolver connections are disconnected or if the battery goes dead after the robot has been stationary for a long period of time, the manipulator’s axis positions will not be stored and must be updated. The axis positions are updated by manually jogging the manipulator to the synchronised position and then, using the teach pendant, setting the counters to zero. If you try to start program execution without doing the above, the system will give an alarm to indicate that the system is not calibrated.

Measuring points for the measurement system are located on the backplane, X9 Maintenance plug, see chapter 9 for more detailed information.

Note that it is necessary to re-calibrate after the resolver lines have been disconnected. This applies even if the manipulator axes have not been moved.

Transmission errors are detected by the system’s error control, which alerts and stops program execution if necessary.

Common causes of errors in the measurement system are line breakdown, resolver errors and measurement board interference. The latter type of error relates to the 7th axis, which has its own measurement board. If it is positioned too close to a source of interference, there is a risk of an error.

1.11 Disk Drive

The disk drive is controlled by the I/O computer via a flat cable. The power is supplied by a separate cable.

Common types of error are read and write errors, generally caused by faulty diskettes. In the event of a read and/or write error, format a new, high quality diskette in the robot and check to see whether the error disappears. If the error is still present, the disk drive will probably have to be replaced. However, check the flat cable first.

NB: Never use diskettes without a manufacturer’s mark. Unmarked, cheap diskettes can be of very poor quality.

If the disk drive is completely dead, check the supply voltage connection to the disk drive to see that it is +5 V, before replacing the drive.

Measuring points are available on the backplane: X9 Maintenance plug, see chapter 9. When replacing the disk drive, check that the strapping is set correctly on the unit. Compare with the faulty drive being replaced.

1.12 Fuses

There is one automatic three-phase 20 A fuse that supplies the DC-link in the **MOTORS ON** state, on the transformer. There is also a automatic three-phase 10 A fuse that supplies the power supply unit. There are also two fuses for customer AC supplies, one 3.15 A and one 6.3 A.

The backplane has four PTC resistance fuses:

- Serial measurement board 1
- Serial measurement board 2
- CAN2, manipulator I/O
- CAN3, external I/O

The fuses protect against 24 V short-circuits and return to the normal state when there is no longer a risk of short-circuiting.

The panel unit has one PTC fuse to protect the motor on chains. An open fuse is indicated on the teach pendant, see *Status of the Panel unit, inputs and outputs, displayed on the teach pendant* side 6, 24 panel.

The cabling from customer 24 V supply is protected by a 2A fuse on terminal XT31 in the upper compartment of the controller.

Note that the power supply unit DSQC 374 is provided with a short circuit energy limitation which makes the fuse unnecessary.

Product Manual IRB 6400R

This chapter is not included in the On-line Manual.

Click on the Main menu button below to continue to the front page.

Main menu

ABB Flexible Automation AB

CONTENTS

CONTENTS

Page

1 General Description

The industrial robot system IRB 6400 comprises two separate units; the control cabinet and the mechanical unit. The service of the mechanical unit is described in this document.

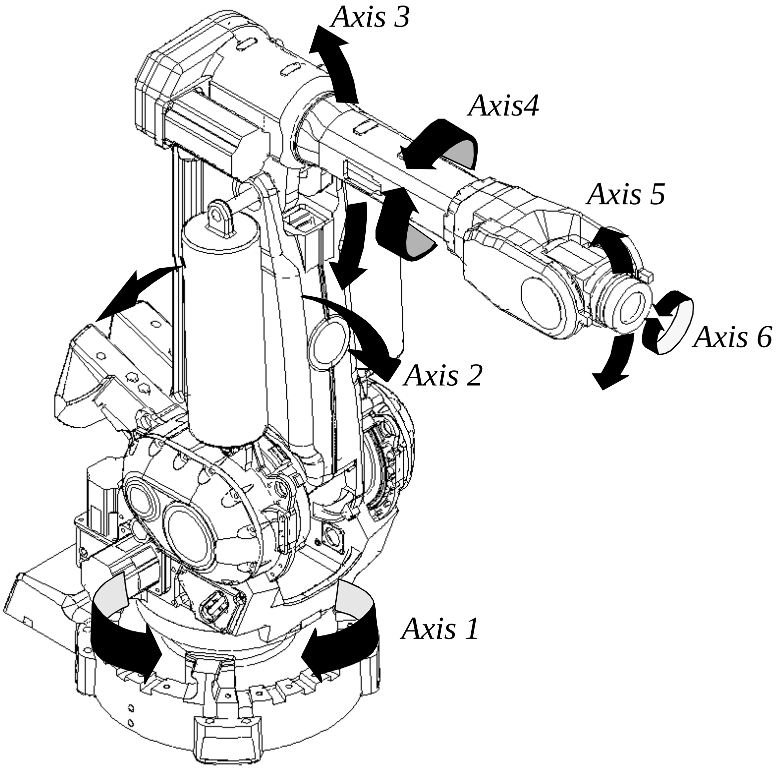
As regards service, the mechanical unit is divided into the following main parts:

- Electrical System
- Motor Units
- Mechanical System

The **Electrical System** is routed through the entire robot and consists of two major systems; power cabling and signal cabling. The power cabling feeds the robot axes' motor units. The signal cabling feeds the various controlling parameters like axis positions, motor revs, etc.

The AC type Motor Units provide the motive power for the various robot axes via gears. Mechanical brakes, electrically released, lock the motor units when the robot is inoperative for more than 180 seconds.

The **Mechanical System** has 6 axes, enabling the flexible robot motions.



Figur 1 The robot axes and motion patterns.

Axis No. 1 rotates the robot via a frame.

Axis No. 2, which provides the lower arm´s reciprocating movement, is supported in the frame. The Lower Arm forms together with the Parallel Arm and the Parallel Bracket, a parallelogram against the Upper Arm. The Parallel Bracket is mounted in bearings in the Parallel Arm and in the Upper Arm.

Axis No. 3 provides elevation of the robot's upper arm.

Axis No. 4, located in the Upper Arm, provides a rotary motion of the Upper Arm.

The Wrist is bolted to the Upper Arm's forward end and comprises the axes Nos. 5 and 6. The latter axes form a cross.

Axis No. 5 provides a tilting motion and Axis No. 6 a turning motion. A connection is arranged for various customer tools at the front end of the wrist in the Turn Disc. The tool (or manipulator) can be equipped with pneumatic control via an external air supply (option). The signals to/from the tool can be supplied via internal customer connections (option).

The Control Cabinet must be switched off during all service work on the robot! Before doing any work on the robot measurement system (measurement board, cabling), the accumulator power supply must always be disconnected.

When service work is finished, the calibration position should always be checked with the system disc.

The Brake Release Unit should be connected as indicated in Section 7, Installation and Commissioning, to enable movements of the axes.

Special care must be taken when the brakes are operated manually. This applies particularly when the robot is started up, either for the first time or after a stoppage. The safety instructions in the Programming Manual must be complied with at all times.

1.1 Document Guidance

The subsequent chapters describe the type of service work that can be carried out by the Customer´s own service staff on site. Certain types of work, requiring special experience or special aids, are not dealt with in this manual. In such cases, the defective module or component should be replaced on site. The faulty item should be sent to ABB Flexible Automation for service.

Calibration. Recalibration of the robot may have to be carried out after replacing mechanical unit parts or when the motor and feedback unit have been separated; or when a resolver error has occurred or the power supply between a measurement board and resolver has been interrupted. The procedure is described in detail in **Chapter 9, Calibration**.

IMPORTANT! When work is done on the robot signal cabling, this may result in the robot moving to incorrect positions.

After doing such work, it is important that the robot calibration position is checked as described in Chapter 11.2, Checking the calibration position. If a calibration fault is discovered, the robot must be recalibrated as described in Chapter 9, Calibration.

Tools. Two types of tools are required for various service jobs involving dismantling; on the one hand, conventional tools like socket and ratchet spanners, etc.; on the other hand, special tools may be necessary, depending on what type of service is being carried out. The conventional tools are not dealt with in this manual, based on the assumption that the service personnel have sufficient technical basic competence. However, service work requiring the use of special tools is described in this manual.

Exploded views. In the Spare Parts chapter of this manual, there are a number of exploded view foldouts illustrating the robot parts, intended to facilitate quick identification of both the type of service required and the composition of the various components. The parts are item numbered on the foldouts. The foldouts are referred to in the Manual text within "arrow heads" (< >) as exploded view numbers. Where reference is made to foldouts, other than those specified in the paragraph title, the foldout number is included in the item number reference, for example <5/19> or <10:2/5>, the digit(s) before the slash referring to the foldout number.

Numbers in brackets ( ) refer to figures in the text.

The foldouts also include information such as article number, designation and relevant data.

N.B. This manual is not to be considered as a substitute for a proper training course. This document is intended for use after the course has been completed.

1.2 Caution

The mechanical unit contains several parts which are too heavy to lift manually. As these parts must be moved with precision during any maintenance and repair work, it is important to have a suitable lifting device available.

The robot should always be switched to MOTORS OFF before allowing anyone to enter its working space.

1.3 Mounting Instructions for Bearings and Seals

1.3.1 Bearings

1. Let a new bearing remain in its wrapping until it is time for fitting, to avoid contamination of the bearing.

2. Ensure that all parts included in the bearing fitting are free from burrs, grinding waste and other contamination. Cast components must be free from foundry sand.

3. Bearing rings, inner rings and roller elements must under no circumstances be subjected to direct impact. Also, the roller elements must not be exposed to any stresses during the assembly work.

Tapered Bearings

4. The bearing should be tensioned gradually until the recommended pre-tension is achieved.

5. It is important to note that the roller elements must be rotated a specified number of turns before pre-tensioning is carried out, and also rotated during the pre-tensioning sequence.

6. The above procedure must be carried out to enable the roller elements to adjust to the correct position against the race flange. Also, it is important that the bearing is properly aligned, as this will directly affect the lifespan of the bearing.

Greasing Bearings

7. The bearing must be greased after fitting. The main reason for this is the requirement for cleanliness. Good quality lubricating grease should be used, for example 3HAB 3537-1.

8. Grooved ball bearings should be filled with grease from both sides.

9. Tapered roller bearings and axial needle bearings shall be greased in the split condition.

10. The bearings must not be completely filled with grease. However, if space is available beside the bearing fitting, the bearing may be totally filled with grease when mounted, as surplus grease will be thrown out from the bearing when the robot is started up.

11. During operation, the bearing should be filled to 70-80% of the available volume.

12. Ensure that grease is handled and stored properly, to avoid contamination.

1.3.2 Seals

1. The commonest cause of leakage is incorrect fitting.

Rotating Seals

2. The sealing surfaces should be protected during transport and mounting.

3. The seal should be kept in the original wrappings or be well protected.

4. Sealing surfaces must be inspected before mounting. If scratches or damage are found, that may result in future leakage, the seal must be replaced.

5. Seals should also be checked before mounting to ensure that:

   - there is no damage to the sealing edge (feel with a fingernail)
   - the seal is of the correct type (provided with cutting edge)
   - there is no other damage.

6. Grease the seal just before fitting it, but not too early as there is a risk of dirt and foreign particles adhering to the seal. The space between the dust tongue and sealing lip should be filled to 2/3 with grease of quality 3HAB 3537-1. The rubber coated external diameter must also be greased.

7. The fitting of seals and gears must be carried out on clean workbenches.

8. Mount the seal correctly. If it is misaligned, there is a risk of leakage due to the pumping effect.

9. Always mount the seal with a mounting tool. Never hammer directly on the seal, as this may result in leakage.

10. Use a protective sleeve for the sealing lip during mounting, when sliding over threads, keyways, etc.

Flange Seals and Static Seals

11. Check the flange surfaces. They must be even and free from pores. It is easy to check flatness using a gauge on the fastened joint (without sealing compound).

12. Differences in surface level or the presence of burrs due to incorrect machining are not permissible. If flange surfaces are defective, the parts must not to be used, because leakage could result.

13. The surfaces must be properly cleaned in accordance with ABB Flexible Automation recommendations.

14. Distribute the sealing compound evenly over the surface, preferably with a brush.

15. Tighten the screws evenly when fastening the flange joint.

O-rings

16. Check the O-ring grooves. The grooves must be geometrically correct and free from pores and contamination.

17. Check the O-ring with regard to surface defects, burrs, shape accuracy, etc.

18. Ensure that the correct O-ring size is used.

19. Tighten the screws evenly when assembling.

20. Defective O-rings and O-ring grooves must not be used.

21. Fitting defective parts will result in leakage. Grease the O-ring with lubricant 3HAB 3537-1 before mounting.

1.4 Instructions for Tightening Screw Joints

General

It is of the utmost importance that all screw joints be tightened with the correct torque.

Application

The following tightening torques are to be used for all screw joints in metallic materials unless otherwise specified in the text.

These instructions do not apply to screw joints comprising soft or brittle materials.

For screws with a higher property class than 8.8, the data for 8.8 must be used unless otherwise specified.

Screws treated with Gleitmo (lubricated)

When handling screws treated with Gleitmo, protective gloves of nitrile rubber type should be used.

Screws treated with Gleitmo can be unscrewed and screwed in again 3-4 times before the slip coating disappears. Screws can also be treated with Molycote 1000.

When screwing in new screws that are not Gleitmo treated, these should first be lubricated with Molycote 1000 and tightened to the specified torque.

Assembly

Lubrication with molybdenum disulphide grease (Molycote 1000) should only be used when specified in the text.

Screws lubricated with Molycote 1000 and then torque tightened, should also to be lubricated between the washer and the head of the screw.

Screws with dimension M8 or larger should be tightened with a torque-wrench, if possible.

Screws with dimension M6 or smaller may be tightened to the correct torque using tools <u>without</u> torque indication, by personnel with adequate mechanical training and instruction.

1.5 Tightening Torques

1.5.1 Screws with slotted or cross recessed head

	Tightening torque - Nm
Dimension	class 4.8 “Dry”
M 2.5	0.25
M 3	0.5
M 4	1.2
M 5	2.5
M 6	5.0

1.5.2 Screws with hexagon socket head

	Tightening torque - Nm		
Dimension	class 8.8 “Dry”	class 10.9 Molycote 1000 Gleitmo 610	class 12.9 Molycote 1000 Gleitmo 610
M 5	6		
M 6	10		
M 8	24	28	35
M 10	47	55	70
M 12	82	95	120
M 16	200	235	300

2 Motor units

2.1 General

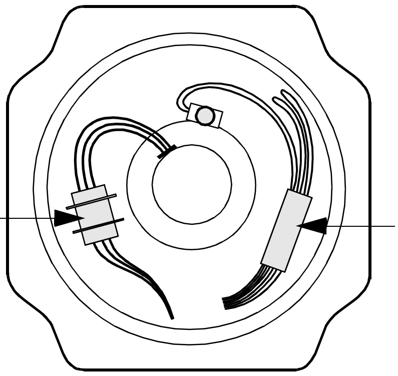
Each manipulator axis is provided with a motor unit consisting of:

- A synchronous AC motor
- A brake unit
- A feedback unit.

A gear on the output shaft of the motor forms together with the gear on each axis, The electro-magnetic brake is built into the motor unit. The brake is released by a 24 V DC supply. For brake release see Section 7, Installation and Commissioning. The feedback unit consists of a resolver mounted on the motor shaft and is built into the motor unit in a similar way as the brake.
Power and signal connections to the motor units are via separate cables between connections points inside the manipulator and each motor. The cables are connected to the motor units with connectors.

- The feedback unit is fitted by the motor manufacturer and must never be separated from the motor.
- The communication angle is + 90° (COMOFF=2048).
  The motors never need commutating.
- The motor, resolver and brake is to be regarded as an replacement motor unit. Faulty motor units are repaired by the motor manufacturer at the request of the ABB Flexible Automation service organisation.
- The cable routing is shown in Figure 2. Note that the signal connection and the power connection must not be entwined.

Signal connection



Power connection

Figure 2 Cable routing in the motor unit.

3 Motors Axes 1-3

3.1 Motor axes 1

Refer to foldout no. 2:5.

Dismounting:

Be careful not to tap or hit the shaft axially, nor displace the shaft axially in any way, as this could give rise to an incorrect air gap in the brake.

1. Unscrew the motor flange, 4 screws <104>.
2. Unscrew the 3 screws on the top of the motor.<3-5> Remove the cover.
3. Disconnect connectors R2.MP1 and R2.FB1 in the motor.
4. Use a portable power supply 24V DC to release the breaks (pin no.11, +24V and pin no.12, 0V) so it is possible to pull out and turn the motor and minimise the risk of damaging the pinion and gear.
5. Attach a hoist and the lifting device (3HAC 6875-1) to the motor. The weight of the motor is 17 kg.
6. Pull and turn out the motor. In case of difficulty use two screws in the threaded holes (M8) on the motor flange to push out the motor from its attachment.

Mounting:

7. Ensure that sealing surfaces are clean and not scratched.
8. Apply oil to the sealing surfaces to ensure that the O-ring runs smoothly
9. Release the brakes.
10. Attach a hoist and the lifting device (3HAC 6875-1) to the motor.
11. Turn the motor carefully so that the pinion and the gears in the gearbox fits together.
12. Apply Loctite 243 to the four screws and tighten with a torque of 50 Nm.
13. Calibrate the robot as described in Chapter 9, Calibration.
14. Refit the connectors and the cover.

Tightening torque:

Screws for motor, item 3: 50 Nm.

3.2 Motor axes 2 and 3

Refer to foldout 2:5.

Dismounting:

Be careful not to tap or hit the shaft axially, nor displace the shaft axially in any way, as this could give rise to an incorrect air gap in the brake.

1. Release the breaks on that axis where the motor change should be done, to ensure that the manipulator axis is disengaged or in what way the axis is moving.

2. Then you can lock the axis into place by mounting a moveable stop, to prevent the axis from falling.

3. Drain the gearbox oil (see Chapter 2.6, Oil change gear box, axes 2 and 3) and unscrew the motor flange, 4 screws <104>.

4. Unscrew the 3 screws on the top of the motor <3-5>. Remove the cover.

5. Disconnect connectors R2.MP1 and R2.FB1 from the motor.

6. Use a portable power supply 24V DC to release the breaks (pin no.11, +24V and pin no.12, 0V) so it is possible to pull and turn the motor out and minimise the risk of damaging the pinion and gear.

7. Attach a hoist and the lifting device (3HAC 6876-1) to the motor. The weight of the motor is 17 kg.

8. Pull and turn out the motor, in case of difficulty use two screws in the threaded holes (M8) on the motor flange to push out the motor from its attachment.

Mounting:

9. Ensure that sealing surfaces are clean and not scratched.

10. Apply oil to the sealing surfaces to ensure that the O-ring runs smoothly.

11. Attach a hoist and the lifting device (3HAC 6876-1) to the motor.

12. Release the breaks and turn the motor carefully so that the pinion and the gears in the gearbox fit together.

13. Refit the connectors and the cover.

14. Apply Loctite 243 to the four screws and tighten with a torque of 50 Nm.

15. Calibrate the robot as described in Chapter 9, Calibration.

Tightening torque:

Screws for motor, item 4, 5: 50 Nm.

4 Motors and Gears Axes 4-6

4.1 Motor axis 4

Refer to foldout 2:10

Dismounting:

1. Drain the gearbox by removing oil plugs <48>.
2. Secure axis 4 so it cannot rotate when the motor is removed.
3. Attach a hoist and the lifting device (3HAC 3HAC 6875-1) to the motor
4. Release the breaks so it will be possible to pull and turn the motor out and minimise the risk of damaging the pinion (see 2.5 Manually releasing the brakes).
5. Unscrew the 4 cable inlet cover screws.
6. Unscrew the 3 screws on the top of motor 4. Remove the cover.
7. Disconnect connectors R2.MP4 and R2.FB4.

Be careful not to tap or hit the shaft axially, nor displace the shaft axially in any way, as this could give rise to an incorrect air gap in the brake.

8. To press the gear off the motor shaft, oil must be injected into the centre of the gear. Mount SKF Oil injector 226270 + SKF nipple 725 870 + 234 063 in the centre and press the gear off the shaft.

Caution: Make sure that the oil injector is filled with oil.

Mounting:

9. Remove the B-side cover at the rear of the motor and place support 3HAA 7601-070 under the motor shaft, to avoid axial loading of the bearings in the motor.
10. Clean the pinion hole on the motor with Ethanol, art. no. 1177 1012-205 and dry with a clean piece of paper.
11. Clean the pinion shaft in the same way.
12. Apply some mineral oil (BP-CS 320) on the pinion shaft and in the pinion hole on the motor. Wipe off any surplus with paper, leaving a thin film of oil on the surfaces.
13. Press the gear on to the motor shaft with a minimum pressure of 250 bar (corresponds to a press force of 1.5-2 t). Use tools 3HAA 7601-070 and 3HAB 5674-1.
14. If the pressure is less than 250 bar or if the pinion “jumps” in intermittently, the pinion must be removed, cleaned, and oiled again before mounting.
15. The total indicated runout of the pinion must not be more than 0.01 mm.
16. Reconnect connectors R3.MP4 and R3.FB4. Mount the cover.
17. Release the breaks, mount O-ring <49> and insert the motor. Turn the motor carefully so that the pinion and the gears in the gearbox mesh together.
18. Apply Loctite 243 and tighten screws <25>, torque 24 Nm.
19. Fill the gearbox with oil, type ABB 1171 2016 -604, volume 6 litres. Regarding replacement oils see the Maintenance Manual IRB 6400R.
20. Calibrate the robot as described in Chapter 9, Calibration.

Tightening torque:

Screws for motor, item 31.25:	24 Nm

4.2 Intermediate gear

Refer to foldout 2:10.

Dismounting:

1. Drain the gearbox of oil.
2. Secure axis 4 mechanically.
3. Remove the cover <28>.
4. Remove the motor as described in Chapter 4.1, Motor axis 4.
5. Unscrew the screws <14>.
6. Unscrew nuts <18> and remove the wedges <17> and remove screws <14>.
7. Pull out the intermediate gear unit.

Mounting:

8. Mount the gear and tighten screws <15.14> only very slightly.
9. Refit the motor as described in Chapter 4.1, Motor axis 4.
10. Adjust the play by moving the intermediate wheel to obtain the minimum play between the final gear and the motor gear, at four points, by turning axis 4. Ensure that when axis 4 is turned, the gears do not “scrape” together.
11. Tighten screws <15.14> with a torque of 69 Nm.
12. Insert the 3 wedges <17> with 12 tension washers <43> and the nut <18> on studs <16>, apply Loctite <39> and tighten with a torque of 8 Nm.

Note! Fit the tension washers with their concave sides facing each other.

NOTE! Check the play.

13. Mount cover <28> with screw <30>and washer <31> with a new seal <29> and tighten with a torque of 10 Nm.
14. Fill the gearbox with oil, ABB 1171 2016-604, volume 6 litres. Regarding replacements oils, see the Maintenance Manual IRB 6400.
15. Calibrate the robot as described in Chapter 9, Calibration.

Tightening torque:

Screws for motor, item 25:	50 Nm.

4.3 Axes 5 and 6

The wrist includes axes 5 and 6 and forms a complete exchangeable unit, comprising motor units and gears.

See spare parts list for types of wrist that can be supplied and for article numbers.

Some maintenance and repair work can be carried out by your own service personnel:

- Oil change as described in the Maintenance Manual IRB 6400.
- Change of motor and gear, axis 6.
- Change of motor, axis 5.
- Checking play, axes 5 and 6.
- Adjusting play in axis 5.

When a complete service of the wrist is required, including mounting/adjusting of gear axis 5, the wrist should be sent to ABB Flexible Automation for service.

4.4 Wrist

Refer to foldout 2:8

Dismounting:

1. Remove the cables to motor axis 6 as in 7.3 Cabling, axis 6.
2. Attach a hoist to the wrist, so that it cannot rotate. See Figure 3 To prevent the wrist from rotating..

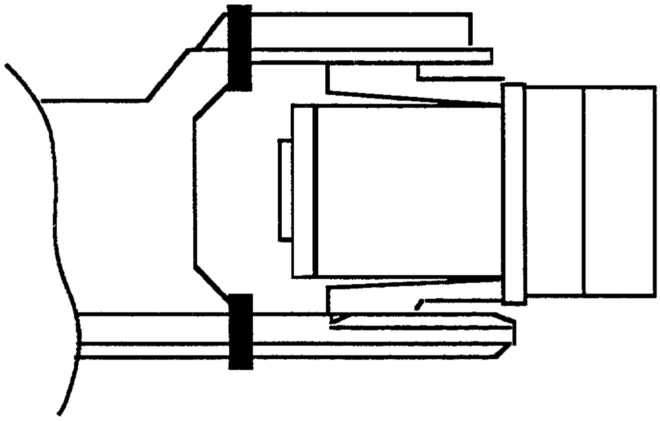


Figure 3 To prevent the wrist from rotating.

3. Unscrew screws <6>.
4. Pull out the wrist from the upper arm (if an arm extender is mounted, the cables must be dismounted before pulling out the wrist) see chapter 4.5 Arm extender.
5. Dismount cables to motor axis 5

Mounting:

6. Mount cables to motor axis 5.
7. Lubricate screws <6> with Molycote 1000 and tighten with a torque of 120 Nm.
8. Mount cabling to axis 6.
9. Pressure test Foundry robots as described in Chapter 7.3, Cabling, axis 6.
10. Calibrate the robot as described in Chapter 9, Calibration.

Tightening torque:

Screw joint wrist/tube shaft, item 33: 120 Nm

4.5 Arm extender

Refer to foldout. 2:8, 2:9.

Dismounting:

1. Dismount the wrist as described in Chapter 4.4, Wrist.
2. Connect a hoist to the extender <3>.
3. Unscrew screws <2:8/6> for the extender and remove it.

Mounting:

4. Lift the extender in position.
5. Lubricate the screws <2:8/6> with Molycote 1000 and tighten with a torque of 120 Nm.
6. Mount the wrist as described in Chapter 4.4, Wrist.

Tightening torque:

Screw joint extender/tube shaft, item <2:9/3>: 120 Nm

4.6 Dismounting Motor axis 5

Refer to foldout 2:11.

Dismounting:

1. Dismount the wrist as described in Chapter 4.4, Wrist.
2. Drain the oil by opening both magnetic plugs.
3. Remove screw <3>. Press out the motor <2> with pin screws (M8x65). Keep track of the shims <7> between the motor flange and wrist housing.
4. Measure the distance between the motor flange and the outer surface of the gear. Use tool 6896 134-GN. Make a written note of the distance.

Be careful not to tap or hit the shaft axially, nor displace the shaft axially in any way, as this could give rise to an incorrect air gap in the brake.

5. Press out the gear from the shaft. Use nipple 6896 134-AA + TREDO washer as a seal + SKF nipple 101 8219 + SKF oil injector 226270.

Caution: Make sure the oil injector is filled with oil.

N.B.
This gear is matched with the other parts of the bevel gear <5> for axis 5. If the motor is changed, the gear must be moved over to the new motor axis. If the gear is damaged, the complete bevel gear set unit must be replaced.
Please contact ABB Flexible Automation when replacement of the bevel gear set unit is necessary.

6. Press the gear on to the new motor. Use tools 3HAA 7601-070 + 3HAB 5674-1.

Note!
Remove the cover at the rear of the motor and place support 3HAA 7601-070 under the motor shaft, to avoid axial loading of the bearings in the motor.

7. Check the distance to the gear with tool 6896 134-GN. If the distance differs from the earlier measurement, an adjustment must be made by adding or removing shims <7>.
8. Release the brake. Mount the motor. Use a new O-ring <2.3>. Apply Loctite 243 on screws <3> and tighten with a torque of 24 Nm.
9. Fill the gearbox with oil according to the Maintenance Manual IRB 6400R.

Tightening torque:

Screw joint motor/wrist housing, item 3: 24 Nm

4.7 Motor/gear axis 6.

Refer to foldout no 2:11§
It is not necessary to remove the wrist from the upper arm.

Dismounting:

1. Dismount cabling for axis 6 as described in Chapter 7.3, Cabling, axis 6.
2. Drain the grease. Open both magnetic plugs.
3. Loosen screw <2:11/31> and remove the cover <2:11/38> Note! It is not necessary to drain the wrist, before removing the cover.
4. Dismount cover <2:11/16> by deforming it (a new cover must be mounted).
5. Unscrew screws <2:11/13>. Dismount shaft <2:11/12> with help of pinscrews M8x65).
6. Loosen screws <2:11/33>.
5. Free the drive unit from the shaft <2:11/34> and lift out.
6. Loosen screws <2:12/4>. Dismount the gear with the help of 2 screws (M8 holes in the motor flange).
7. Loosen screws <2:12/5>. Dismount the pinion with tool 3HAA 7601-043.

Mounting:

8. Mount the pinion on a new motor. Use a pin screw, M5x120 with nut, to press the gear in place. Tighten screw <2:12/5>, apply Loctite 243.

NOTE!
Be careful not to tap or hit the shaft axially, nor displace the shaft axially in any way, as this could give rise to an incorrect air gap in the brake.

9. Mount the gear on the motor, tighten with screws <2:12/5>. Use a new O-ring <2:12/2>. Turn the gear so that the screw hole and magnetic oil plug come in the right position. Torque 35 Nm.
10. Move the sync plates and connector holder on the resolver side, over to the new motor. When dismounting the gear: the sync plate <2:12/11> on the gear is glued.
    It is most important to clean the surface before applying the sync plate.
    Use Ethanol, art. no. 1177 1012-205 and paper to clean.
    Remove the dirt by wiping from the left to right just once. Change the paper and wipe again, the same way. Continue until no dirt appears on the paper.
11. Mount the motor unit in the wrist. Fix against the shaft item <2:11/34>. Tightening screws <2:11/33> torque 69 Nm. Mount shaft <2:11/12> with screws <2:11/13> with Loctite 243 tightening torque 24 Nm.
12. Mount cover <2:11/16> (new cover) and cover <2:11/38>. Use a new gasket <2:11/28>. Cross tighten screws <2:11/31> to 10 Nm.
13. Fill oil in axis 5 as described in to the Maintenance Manual IRB 6400R.
14. Pour grease into axis 6 as described in the Maintenance Manual IRB 6400R.
15. Calibrate the robot as described in Chapter 9, Calibration.

Tightening torque:

Screw joint motor/gear, item 4:	35 Nm
Screw joint, drive unit/ gear 5, item 15:	69 Nm
Screw joint, drive unit/shaft, item 33:	24 Nm
Cover, item 31:	10 Nm

4.8 Checking play in axes 5 and 6

Refer to foldout no. 2:11.

Axis 5

1. Drain the oil. Unscrew both the magnetic plugs. Dismount cover <2:11/38>.
2. Mount fixing plate 6896 134-CE in 3 screw holes for the cover.
3. Mount a PEK dial indicator with a magnetic foot on the fixing plate. Measure against the front part of the turning disc, at D=160 mm, B= 8 mm. See Figure 4 How to measure the play in the wrist.
4. Use tool 6896 134-CD or mounted equipment to check the total play in axis 5. The brake must be on. Max. play 0.30 mm at a distance of 196 mm from the centre of axis 5. (Max. play for a new wrist is $\leq$ 0.25 mm).
   Adjustment: See Chapter 4.9.1, Adjusting the intermediate gear unit

Axis 6

1. Check the play in axis 6 with tool 6896 134-CF.
2. Measure with a PEK dial indicator against the tool. See Figure 4 How to measure the play in the wrist..
3. Max. play 0.06 mm at a distance of 190 mm from the centre of axis 6.
   Comment: The play in the gear unit <u>cannot</u> be adjusted. If necessary, the gear unit must be replaced, see Chapter 4.7, Motor/gear axis 6..

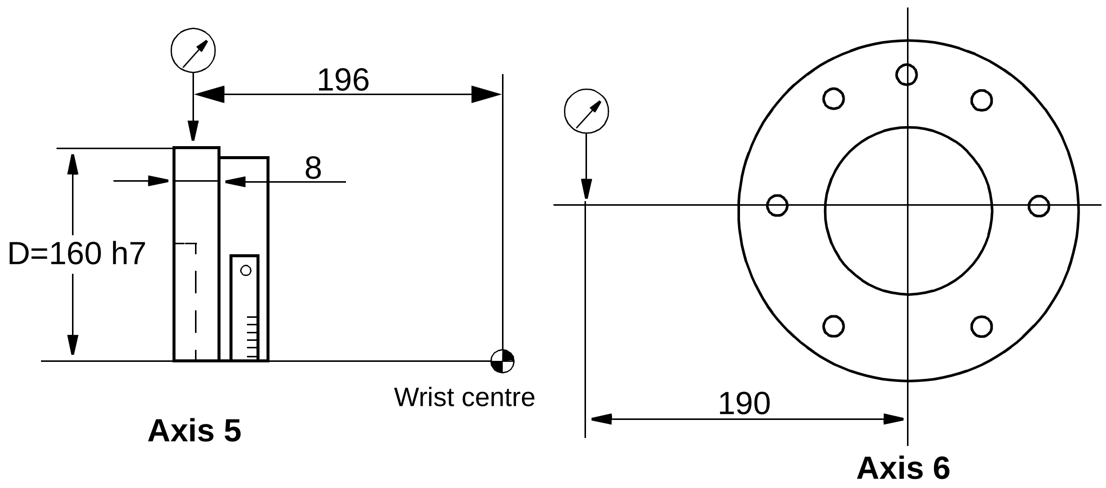


Figure 4 How to measure the play in the wrist.

4.9 Adjusting play in axis 5

Refer to foldout.2:11.

1. Remove the cover <2:11/38>. Investigate the cause of the excessive play on axis 5. Then take action as described in one of the following alternatives:

A. The intermediate gear unit <2:11/37> is stuck, the play between gears <2:11/5> and <2:11/34> is excessive. The play must be 0 to 0.08 mm, measured at three different points.

Action: Adjust the play as described in ***Chapter 4.9.1, Adjusting the intermediate gear unit***.

B. The intermediate gear unit <2:11/37> has become loose. Check that the gears <2:11/5> and other parts (<2:11/18>, <2:11/20>, <2:11/21>, <2:11/22> and <2:11/43>) are not damaged or loose.

Action: Replace damaged parts and adjust the play as described in ***Chapter 4.9.1, Adjusting the intermediate gear unit***

C. There is play in the bearings of the intermediate gear unit <10/105>.

Action: Adjust the bearing as described in Chapter 4.9.2, Adjusting the intermediate gear unit bearings and adjust to the correct play as described in ***Chapter 4.9.1, Adjusting the intermediate gear unit***.

4.9.1 Adjusting the intermediate gear unit

Refer to foldout. 2:11.

1. Remove the wedges <2:11/21>. Check that they are not damaged.

2. Adjust the intermediate gear unit <2:11/105> with the centre screw <2:11/18>. The gear mesh play between the pinion <2:11:1/2> and the gearwheel must be 0 - 0.08 mm. Measure the play at three different places. Use the tool 6896 134-CE and a dial indicator on a magnetic foot.

3. Tighten the intermediate gear unit <2:11/105> using the screw <2:11/18>, to a torque of 93 Nm ± 5%.

4. Mount the wedges <2:11/21> and the 4 tension washers <2:11/43> (fit them as shown on foldout 2:11).

5. Tighten the wedges alternately with the nuts <2:11/22>. Torque 12 Nm ± 5%. Apply Loctite 243 to lock the nuts.
   Check the gear play after tightening as described in Chapter 4.8, Checking play in axes 5 and 6

Tightening torque:

Screw for intermediate wheel, item 10:1/18:93 Nm ± 5%
Nuts for wedges, item 10:2/22: 12 Nm ± 5%

4.9.2 Adjusting the intermediate gear unit bearings

Refer to Figure 5 Intermediate wheel unit.
The roller bearings (1) must be pretensioned to eliminate any backlash.

1. Remove the stop screw (2) and the locknut (3).

2. Clean the threads in the hub (4) and the locknut (3).

3. Apply Loctite 290 on the threads in the hub and the locknut.

4. Tighten the locknut (3). Torque 85 Nm ± 5% (for a replacement bearing).
   Use the tool 3HAB 1022-1 together with the torque-wrench.

   Note!
   If the same bearing is fitted again, the torque should be 70-75 Nm.

5. Fit the stop screw (2), extra locking. Apply Loctite 243.

   Tightening torque:

   Locking nut in the intermediate wheel, item (3):85 Nm ± 5%

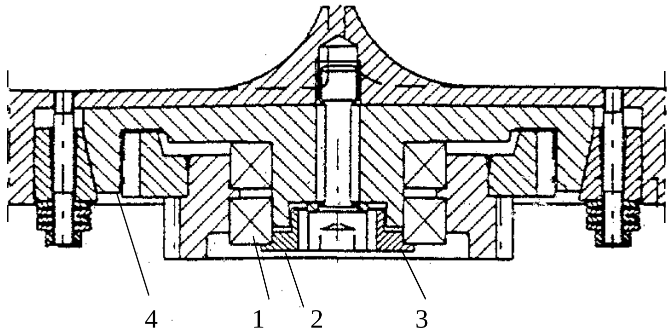


Figure 5 Intermediate wheel unit

5 Balancing unit

5.1 Dismounting balancing unit

Refer to foldout no. 2:13.

Dismounting:

1. Move the lower arm to the sync. position.

2. Insert an M12 screw at the top of the cylinder to neutralise the spring force. The length of the cylinder is now locked.

3. Attach a hoist and the lifting device (3HAC 6877-1) to the balancing unit.

Make sure that the shaft between the upper and lower arms does not rotate when unscrewing the KM nut. The KM nut is locked with Loctite 243 (242).

4. Remove the lock nuts <233> with tool (3HAC XXXX-X) and the support washer <231> and the sealing ring <232>.

5. Pull the balancing cylinder out with hand force.

Mounting (see Figure 6):

5. Place rings (1), support washers (2), sealing rings (3) and the inner races of the bearings on the upper and lower pivot shaft.

6. Install the auxiliary shafts on the upper and lower shafts. (Upper shaft: auxiliary shaft 3HAB 5275-1, lower shaft: auxiliary shaft 3HAB 5276-1.)

7. Hang up the new balancing unit on the upper auxiliary shaft, adjust the length with the M12 screw while pushing the balancing cylinder in place by hand force, and carefully install the balancing unit on to the upper and lower shafts (do not use a hamer of any type, the bearings may be damaged).

8. Fit the lubricating tool 3HAC 5222-1. The tool should be tightened to the bottom position only by hand power.

9. Grease through the nipple. Continue greasing until the grease exudes behind the inner sealing ring. Repeat the procedure for the other bearings.

10. Remove the lubricating tool and clean the threads on the shaft ends free from grease.

11. Remount the outer sealing rings, apply some grease on the support washers, apply Loctite 243 on the KM nuts, not on the shafts, and tighten them to a torque of 50-60 Nm.

12 Check play (min. 0.1) between support washers (2, 5) and bearing seat (7) at both bearings.

13. Remove the M10x50 screw at the top of the cylinder. Remove the M16x140 screw on the lower arm.

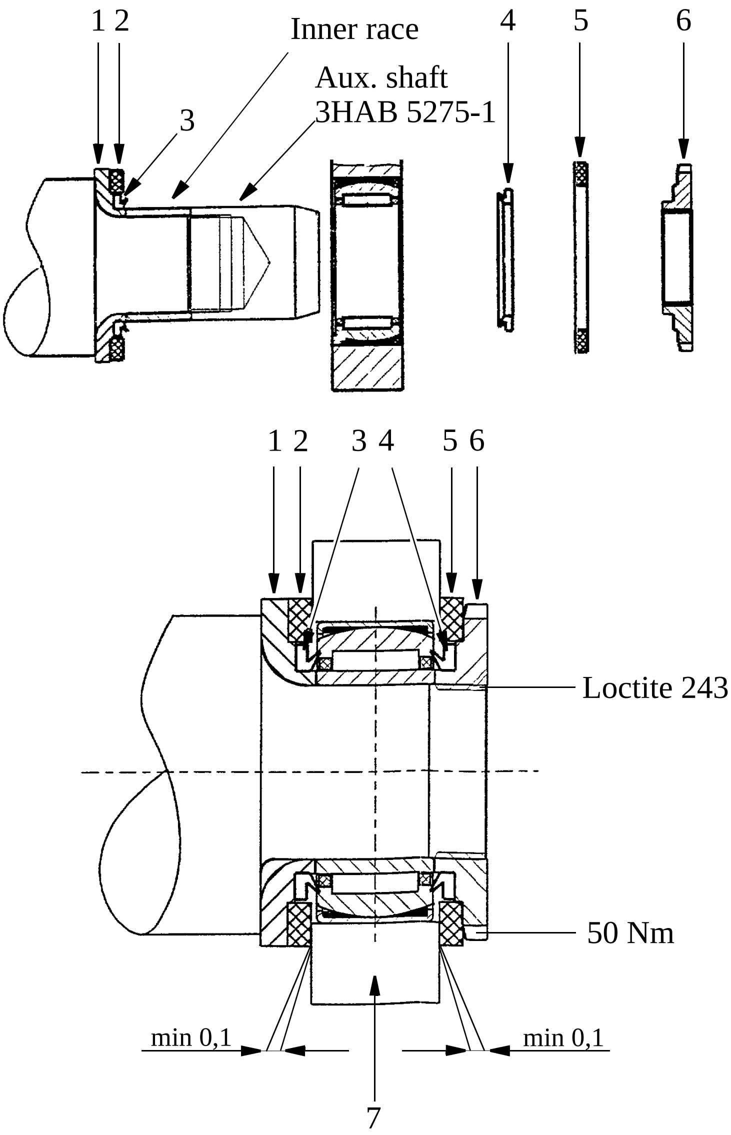


Figure 6 Mounting the balancing unit.

5.2 Replacing guide ring, balancing unit

1 Move axis 2 to a position where the balancing unit is in the horizontal position.

2 Remove the circlip from the end cover of balancing unit. See Figure 7.

3 Remove the worn out guide ring and clean the piston rod. See Figure 7.

4. With the smallest outer diameter facing outwards, force the new guide ring over the piston rod. Use tool 3HAC 0879-1. Locate the ring in the end cover.
See Figure 7

5. Install the circlip.

6. Lubricate the piston rod, see Maintenance, Chapter 2.5, Lubricating piston rod, balancing unit axis 2.

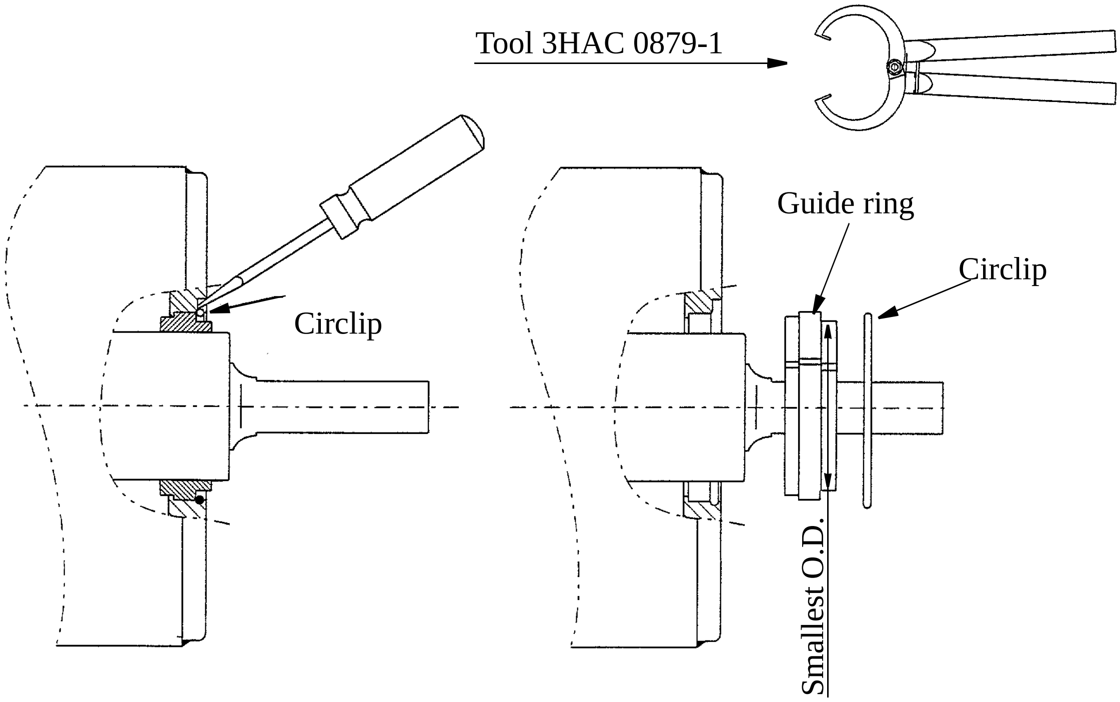


Figure 7 Guide ring, balancing unit.

5.3 Replacing bearings, balancing unit

Use reconditioning kit 3HAC 2840-1.

1. Dismantle the balancing unit according to Chapter 5.1, Dismounting balancing unit.

2. Push out the old bearing, using tool 3HAC 1981-1. See Figure 8.

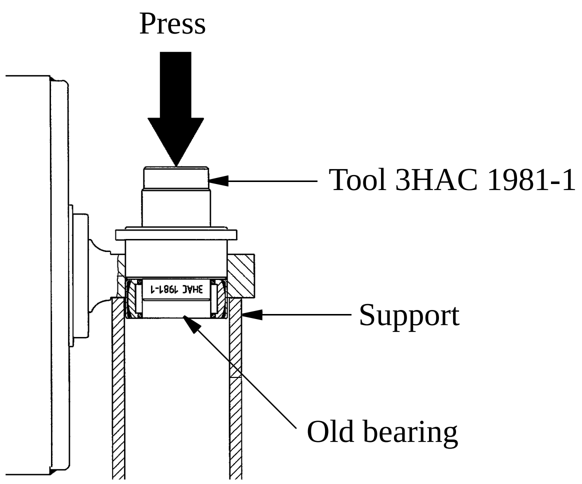


Figure 8 Dismounting of bearing.

3. Turn the tool upside down. Place the new bearing on the tool with the bearing number upwards (facing the tool). Push the new bearing down as shown inFigure 9.

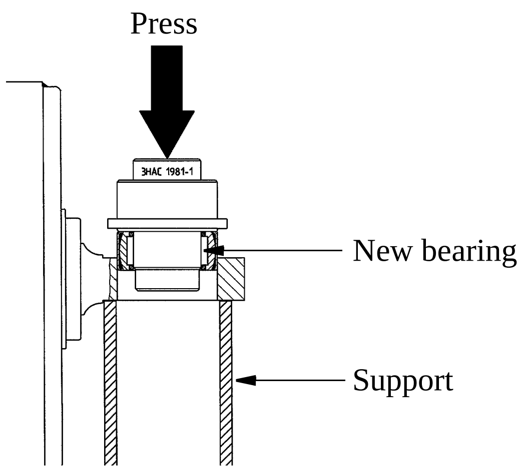


Figure 9 Mounting bearing.

4. Mount the balancing unit according to Chapter 5.1, Dismounting balancing unit.

6 Arm System

6.1 Upper Arm

Refer to foldouts 2:1, 2:3, 2:8,

Dismounting:

IMPORTANT! Secure axis 3 with two extra mechanical stops, so that the balancing weight for axis 3 cannot fall down.

1. Dismount balancing units <2:1/5> as described in 5.1, Dismounting balancing unit or 5.2, Replacing guide ring, balancing unit.
2. Remove the cables and air hose inside the upper arm as in 7.2, Robot Harness / Customer Harness
3. Attach a hoist and the lifting device (3HAC 6878-1) to the upper arm. See Figure 10

.

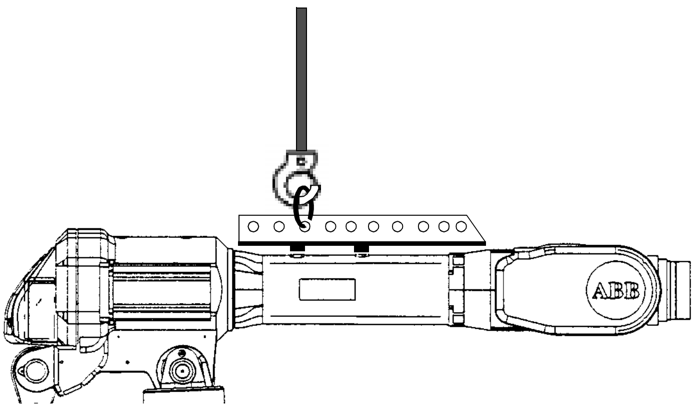


Figure 10 Lifting the upper arm.

4. Remove the parallel arm<2:1/3> see 6.5, Parallel Arm.
5. Remove the KM nut (1) on each shaft. See Figure 11.
6. Remove the stop screws (2) in the lower arm. See Figure 11.
7. Remove the protective plates <2:3/10> on the inner side of the shaft, unscrew the shafts (3). The bearing is pressed out with the shaft. See Figure 11.

Note! Be careful with the threads on the shafts.

8. Lift the upper arm away.

Mounting:

9. Place the upper arm in position.

NOTE! Mount the left side first, complete, robot seen from behind! See Figure 11.

10. Mount V-ring (5) and distance ring (6) on shaft (3).
11. Lubricate the M80 thread and the cone with Molycote 1000.
12. Mount the shaft (3) in the lower arm. Tighten with a torque of 300 Nm.
13. Apply Loctite 243 on stop screw (2) and tighten with 34 Nm.
14. Mount sealing ring (4), turn the largest diameter inwards.
15. Mount and grease the bearing (7).
16. Insert the NILOS ring (8).
17. Insert the distance ring (9).
18. Mount the KM nut (1). Apply Loctite 243 and tighten the nut to 180 Nm, then loosen the nut again and tighten with a torque of 90 Nm.
19. Then mount the right side, paragraphs 12-18 (similar to the left side, except for the distance ring (6).
20. Mount the parallel bar.
21. Mount the cabling as described Chapter 7.2 Robot Harness / Customer Harness.
22. Mount the balancing units as described in 5.1, Dismounting balancing unit.

NOTE! Remove the 2 extra mechanical stops!

Tightening torques:

Shafts, item (3):	300 Nm
KM nut, item (1):	90 Nm
Screws, clamps, item 8/31.3.3:	300 Nm

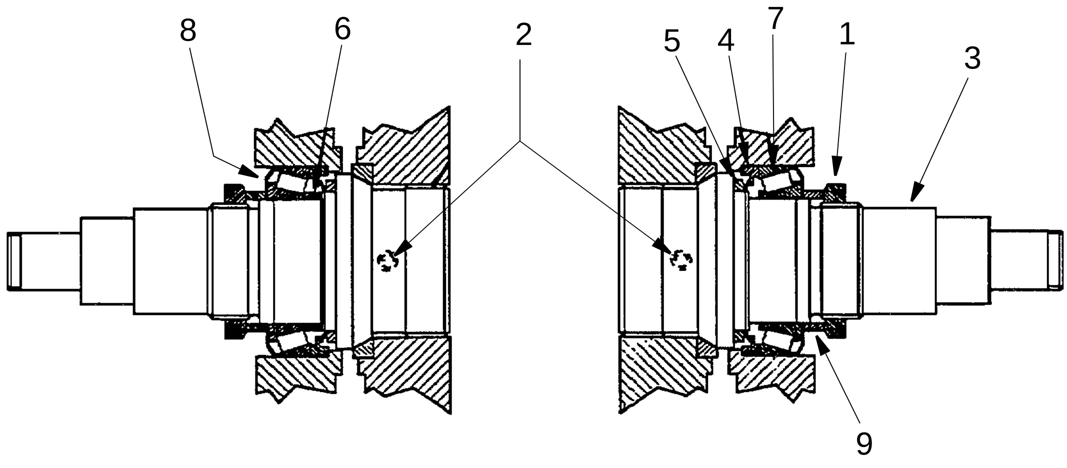


Figure 11 Joint axes 2 and 3

6.2 Parallel bar with bearings

Refer to foldout no. 2:1.

Dismounting:

IMPORTANT! Secure axis 3 with two extra mechanical stops, so that the balancing weight for axis 3 cannot fall down, and secure the upper arm with a hoist or similar.

1. Attach a hoist and lifting device to the parallel bar.

2. Dismount screw and washer <2:1/224, 223> by the parallel arm.

3. Dismount screw and washer <2:1/224, 223> by the upper arm. Lift the bar away.

Mounting:

4. Lift the parallel bar in position.

5. Place the axial washer and cover washer on each side of the bearing

6. Place and centre the parallel bar

7 Apply a thin coat of grease on the shaft

8. Press the shaft with a hydraulic press and tool (3HAC 5026-1)

9. Apply Loctite 243 and mount the screw and washer<2:1/224, 223>.

Do not forget to remove the 2 extra mechanical stops!

6.3 Balancing weight

Refer to foldout 2:1

Dismounting:

1. Attach a hoist with two lifting eyes to the balancing weight.

2. Loosen the four M16 screws.

3. Lift the weight away.

Mounting:

Mount in reverse order.

6.4 Lower Arm

Refer to foldout 2:1,

Dismounting:.

Danger! Be careful! Make sure that the upper arm is locked in position and cannot move.

1. Dismount the balancing weight for axis 3. (see chapter 6.3).

2. Attach a hoist to the upper arm.

3. Remove the locking screw and washer <2:1/223, 224> on the parallel arm and the upper arm, press the shafts out with a hydraulic press and tool no.3HAC 5026-1 and lift the parallel bar away.

4. Remove the harness on the upper and lower arms as described in 7, Cabling.

5. Dismount the upper arm as described in Chapter 6.1 Upper Arm.

6. Dismount the two balancing units <2:1/4> as described in 5.1, Dismounting balancing unit or 5.2, Replacing guide ring, balancing unit.

7. Dismount the M16x70 screws between the parallel arm and gearbox axis 3 and between lower arm and gearbox axis 2, (the lower arm must be reorientated to make it possible to dismount all the screws) save at least two parallel placed screws on each side.

8. Attach a hoist to the lower arm.

Danger! Be sure that the lower arm is properly attached to the hoist before loosening the last screws.

9. Dismount the last four screws.

10. Place a crowbar between the gearbox axis 3 and the parallel arm, and press the lower and parallel arms together.

11. Place a crowbar between gearbox axis 2 and the lower arm, and press to release the guiding.

12. Lift and remove the lower arm.

13. Dismount the parallel arm as in Chapter 6.5 Parallel Arm.

Mounting:

Mounting in reverse order.

6.5 Parallel Arm

Refer to foldout 2:7

Dismounting:

1. Remove the lower arm as in 6.4, Lower Arm.

2. Place the arm on a workbench.

3. Attach a hoist to the parallel arm.

4. Place the Cylinder NIKE CHF 612 (1) and tools 3HAC 5526-1 (2) and 3HAC 5523-1 (3) see Figure 12.

4. Force the parallel arm to the right, seen from the rear.

5. Lift the parallel arm away.

Mounting:

6. Place the parallel arm in position.

7. Press the parallel arm into the lower arm with NIKE CHF 612 (1) and tools 3HAC 5526-1 (2) and 3HAC 5523-1 (3), see Figure 12.

8. Mount the lower arm as described in 6.4, Lower Arm.

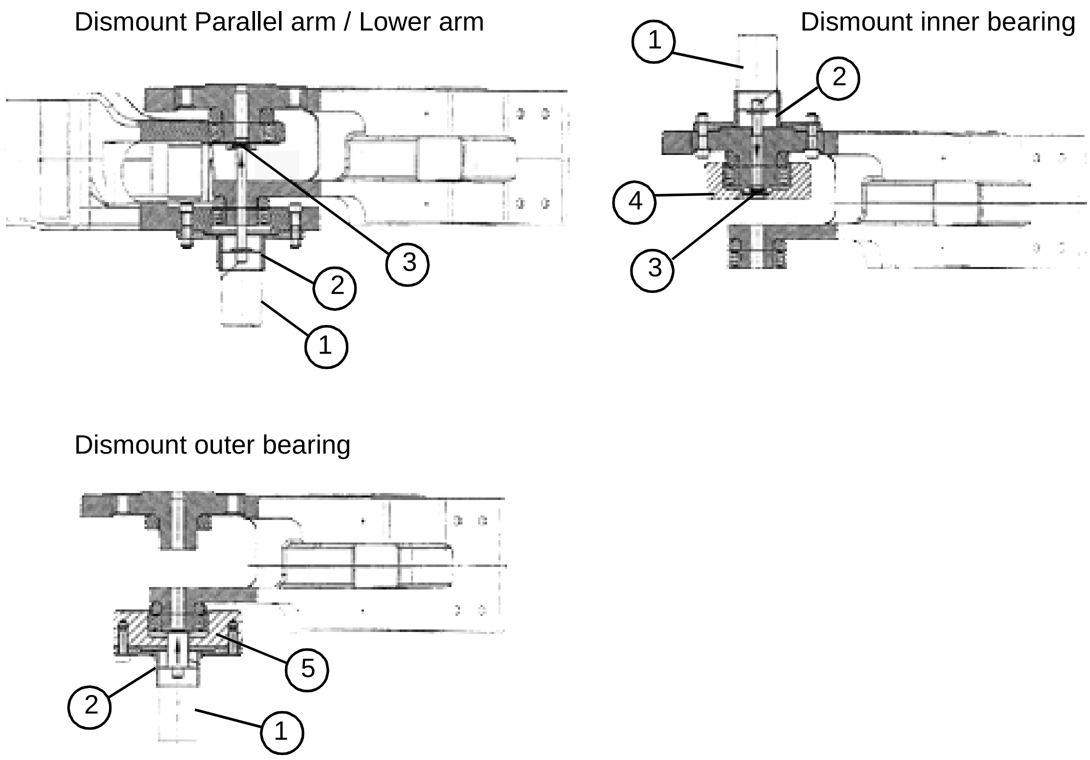


Figure 12 Dismounting Parallel arm and Bearings

6.6 Inner Bearing

Dismounting:

1. Place the cylinder NIKE CHF 612 (1) and tools 3HAC 5526-1 (2), 3HAC 5523-1 (3) and 3HAC 5522-1 (4), see Figure 12.

2. Press the bearing off.

Mounting:

In Reverse Order.

6.7 Outer Bearing

Dismounting:

1. Place the cylinder NIKE CHF 612 (1) and tools 3HAC 5526-1 (2), 3HAC 5523-1 (3) and 3HAC 5522-2 (5) see Figure 12.

2. Press the bearing off.

Mounting:

In Reverse Order.

6.8 Gearbox 1-3 including base

Gearbox 1-3 incl. base should be replaced as one unit. All the necessary parts must be removed before replacing the gearbox.

Dismounting:

1. Dismount the harnesses from the upper and lower arms. (see chapters 7.2 and 7.1).

2. Dismount the balancing weight (see chapter 6.3).

3. Place the robot in the position as shown below and tie the upper and lower arms together with a strap (see Figure 13, Lifting position).

4. Attach a hoist and the lifting device (3HAC 6878-1) to the upper arm.

5. Dismount lower arm (see chapter 6.4, Lower Arm).

4. Dismount Motors axes 1-3 (see chapters 3.1 and 3.2).

5. Dismount the Break release unit and the SMB (see chapters 6.9 and 6.10).

Mounting:

6. In reverse order.

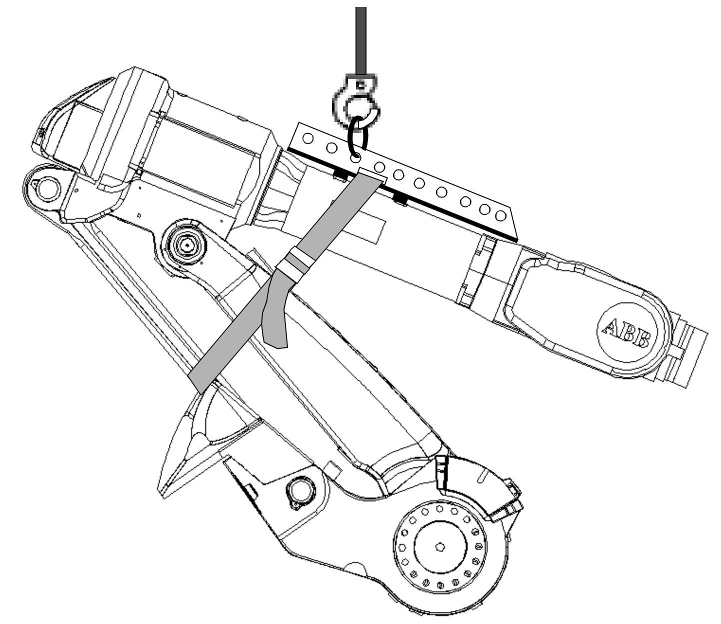


Figure 13 Lifting position

6.9 Brake release unit

Refer to foldout 2:5.

Dismounting:

1. Remove the push-button unit <6> located in the frame.
2. Disconnect connectors R3.BU1-6(X8), R3.BU1-3(X9), R3.BU4-6(X10).

Mounting:

3. In reverse order.

6.10 Replace Serial Measurement Board

Refer to foldout 2:6.

Dismounting:

1. Remove the cover <17> located in the frame.
2. Disconnect connectors R2.SMB, R2.SMB 1-4, R2.SMB 3-6.
3. Disconnect connector R2.G (battery connector) from the SMB.

Mounting:

4. In reverse order.

6.11 Replace Stop pin

Refer to foldout 2:5

Dismounting

1. Remove the cover on top of the housing.
2. Dismount the M20x90 bolt <102> and the compression spring <101>.
3. Lift up the stop pin<8> and the washer<103>

Mounting

4. In reverse order.

7 Cabling

7.1 Integrated Spot Weld Harness

Refers to foldout nos. 2:1, 2:3, 2:5, 2:6 and 2:10

Dismounting

1. Remove the four screws <2:5/100> for the cover <2:5/15> that protects the cable harness in the base.

2. Remove the connectors R1.WELD, R1.PROC1, R1.PROC2 and R1.PROC3 to the welding harness.

3. Unsnap the hose from its fixture between the lower and parallel arms.

4. Remove the hose clamps from the cover <2:5/10> on the base (see Figure 14)

5. Pull the harness up through the base from the front side of the robot (air hoses first).

6. Unsnap the harness from the lower (2) and upper (3) fixtures on the gearbox axis 3 and from the fixture on the lower arm (4). On robots with truck lifts fitted, there is a hose clamp underneath the truck lift (see Figure 15).

7. Remove the connector and air connections from the connector fixture on the upper arm housing.

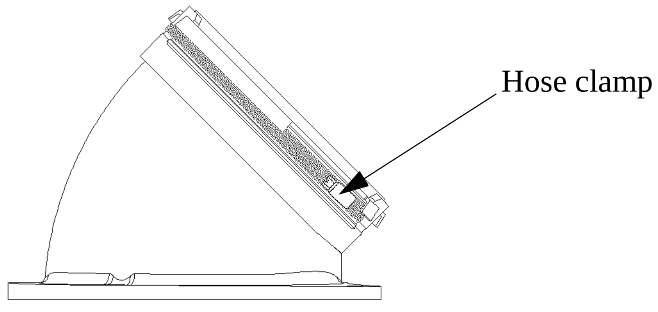


Figure 14 Cable harness clamp

Mounting

8. Start by attaching the harness to the snap fixtures on the gearbox and lower arm.

9. Pull the harness down through the cover <2:5/10> in the base and position it as shown in the picture (see Figure 17).

10. Fit the hose clamp with the screw in the position shown in the pictures (see Figure 14) and (Figure 17).

11. Fit the harness on the snap fixtures between the lower and parallel arms.

12. Fit the connector and air connections to the fixture on the upper arm housing.

13. Fit the connector and air connections in the base.

14. Replace the plate that covers the harness in the base.

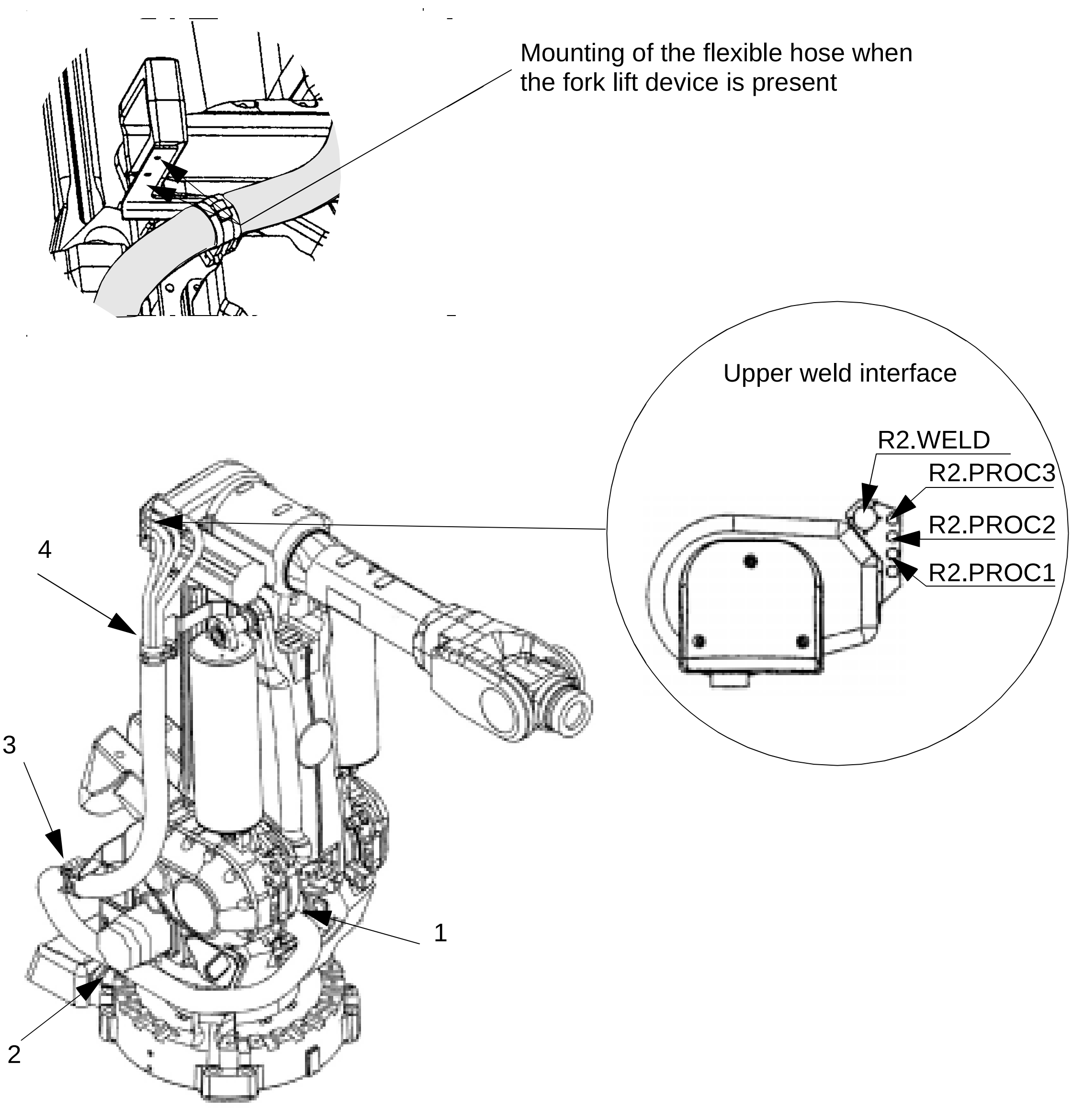


Figure 15 Attachment points for spotwelding harness

Mounting

15. Mount in reverse order.

7.2 Robot Harness / Customer Harness

Refer to foldout no. 2:1, 2:3, 2:5, 2:6 and 2:10

Dismounting:

This section also applies for dismounting a customer harness, but ignore points 2-5 below.

We recommend that a team of at least two people undertake the job of changing a harness.

When the robot is equipped with a welding harness, this must first be removed from the base up to the harness clamp in the base, to facilitate removal of the robot harness (se the section about changing welding harness).

1 Remove the 4 screws <2:5/100> in the cover <2:5/15> that protects the connectors on the base.

2 Remove the connectors R1.MP and R1.SMB from the attaching plate.

2a Remove the connectors R1.SW1, R1.SW2/3, R1.CP/CS from the attaching plate (applies only when a customer harness is fitted).

3 Unscrew the 3 screws on motors 1, 2, and 3 and remove the covers. Remove the connectors from the motors.

4 Remove the brake release units <2:5/6> and the cover of the series measuring board <2:6/17> and remove the connectors.

5 Unscrew the 4 screws from the cable glands to the serial measurement board and the brake release board on the inside of the base and pull out the cables.

6 Remove the cable guide <2:5/42> located between the lower and parallel arms by pressing the split part so it overlaps. Open it up and take out the cables (see Figure 16).

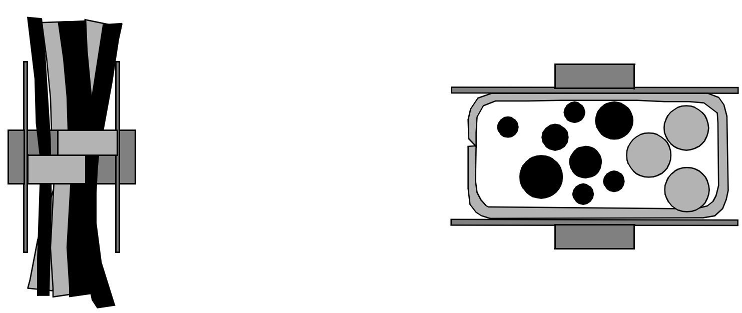


Figure 16 Cable harness guide, axes 2, 3.

7 Remove the hose clamp from the cover <2:5/10> on the base (see Figure 14)

8 Pull the harness up through the base from the front side of the robot.

9 Remove the cover <2:1/7> on the arm housing and unscrew the holders for cable guide <2:1/251> and cable guide <2:1/252> from the tubular shaft.

10 Remove the 4 screws on top of motor 4 and remove the connectors. Unscrew the screws for the clamping strap fixture below motor 4 (new clamping strap fixtures are included with the harness).

11 Remove the cover <2:3/13> on the upper arm tube and remove the connectors to motors 5 and 6.

12 Remove the harness fixtures underneath the arm housing and on the front side of the upper part of the upper arm.

13 Pull the harness out of the tubular axle and down through the lower arm.

It should be remembered that connectors and wiring are sensitive parts of a harness and must be treated with care.

Mounting

14 Start by pulling the harness up through the lower arm and pre-fit the attachment plate for the fixture in the arm housing (there is insufficient space to do this when the harness is in position).

15 The cables to motor 4 are then pulled through the arm housing and fitted before the cables to motors 5 and 6 are pulled through the arm housing.

16 The harness is twisted ½ turn between the attachments in the under arm and upper arm so that the cables have the same length when they are subjected to bending (this twist must be retained).

17 Position the various harnesses correctly in the cover on the base (see Figure 17).

18 Position the screws for the hose clamps at the correct places (see Figure 14).

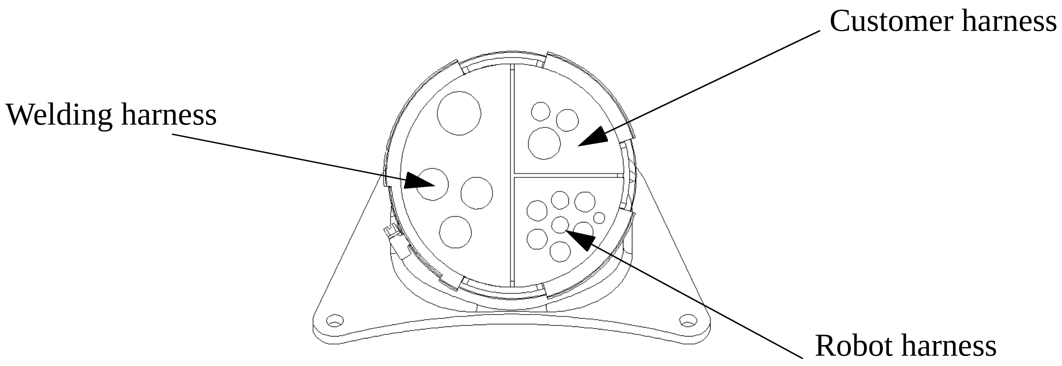


Figure 17 Location of harnesses in holder

7.3 Cabling, axis 6

Refer to foldout 2:8.

Dismounting:

1. Run axis 5 to +90° position.
2. Remove the covers for the cables to axis 6 on the upper arm tube and wrist.
3. Dismount connectors R2.MP6, R2.FB6 from the robot harness. Loosen the cable bracket and the sealing with screws <32>.
4. Dismount the cover at the back of the motor.
5. Dismount connectors R3.MP6, R3.FB6 under the cover at the rear of motor 6. Loosen the cover by using the thread in the centre hole and a suitable tool. Alternative:
   Press the cover out from the inside with a screw driver through the cable pit.
   Note! Be careful not to damage the cables or resolver.
6. Loosen the carrier mounted on the motor with screws <41>.

Mounting:

7. Mount in reverse order. (Keep axis 5 in 90° position.)

Note!
Foundry robots must be tested for leakage after cable replacement.

Test procedure for IRB6400 Foundry axis 6:

1. Remove the plug on the back of the axis 6 motor.
2. Install test device, 3HAC 0207-1 and 3HAC 4618-1, which consists of a gauge, valve, and adapter connected to the compressed air supply.
3. The chamber is pressurised to 0.2 bar and the valve is then closed.

Note!
Be careful not to over-pressurise the chamber.

4. The pressure is then monitored on the gauge to ensure that the loss during a period of 45 seconds does not exceed 0.1 bar.
   This pressure loss is due to air leaking through the cables. It is important that the cables in the upper arm box are connected and the box is closed properly, i.e. the air pressure will be lost in the square shaped Burndy connectors in the axis 1 cavity.
5. If pressure is not maintained, the source of the leak must be located. This is done by spraying a leak detecting fluid around the suspicious areas until the leak has been located.

If a leak is found, take the following action(s):

- In the back cover of the motor - apply latex under the back cover´s flange.
- Around any screw - apply latex under the screw head.
- Leakage through cable exit joints in cup of axis 6 cable assembly - replace the cable.

8 Options

8.1 Cooling axis 1

Refer to foldout 2:14.

Dismounting:

Make sure that the cabinet is powered off when this operation begins.

1. Dismount the two screws and open cover on the fan <1>.
2. Disconnect wires from the connection point.
3. Dismount the three screws at the side of the cover <4>.
4. Replace the fan and the cover.

Mounting:

5. Mount in reverse order.

8.2 Position Switch axis 1

Refer to foldout 2:15

Dismounting:

1. Dismount the protective plates.
2. Dismount the Rail bracket <5> and the 12 screws <8> from the under side of the base.
3. If the cams run into and overlaps on both rail sections, the cams must be dismounted before the rails.
4. Dismount the connector from the bracket on the left side of the manipulator base (seen from behind).
5. Dismount the two screws and remove the position switch.

Mounting:

6. Mount in reverse order.

8.3 Position Switch axes 2-3

Refer to foldout 2:16

Dismounting:

1. Remove the rails by dismounting the M6x60 screws <2:16/8> in the lower arm.
2. Remove the position switch by dismount the four M6x20 screws in the base.
3. If the Spotweld Harness is mounted, it must be removed before the position switch.
4. Disconnect the connector.

Mounting:

5. In reverse Order.

8.4 Signal Lamp

Refer to foldout no. 2:1, 2:10, 2:18

Dismounting:

1. Remove cover on axis 4 <2:1/7>.
2. Dismount the two screws that attach the signal lamp <2:1/117> to the bracket cover axis 4.<2:1/12>.
3. Dismount the three screws on the cover on motor axis 4 <2:10/1> and remove the cover.
4. Dismount the cable gland <2:18/5>.
5. Disconnect the connectors R2.H1 and R2.H2 <2:18/7>.

Mounting:

6. In reverse order.

8.5 Process Media Conduit

Refer to foldout no 2:21

Dismounting:

1. Dismount connectors R1.WELD, R1.PROC1, R1.PROC2 and R1.PROC3 from the plate on the upper arm housing.

2. Dismount connectors R1.WELD, R1.PROC1, R1.PROC2 and R1.PROC3 from the plate on the manipulator foot.

3. Open the snap attachments and dismount the cables.

4. Dismount the upper rail by undoing the two fixtures underneath the base frame (two M6x20 screws per fixture).

5. Dismount the lower rails by undoing the two fixtures on the side of the manipulator foot (one M6x20 screw per fixture).

6. Dismount the brackets on the base frame and foot (one M8x40 screw per bracket).

7. Dismount the snap attachments, see Figure 18, Location of snap attachments.

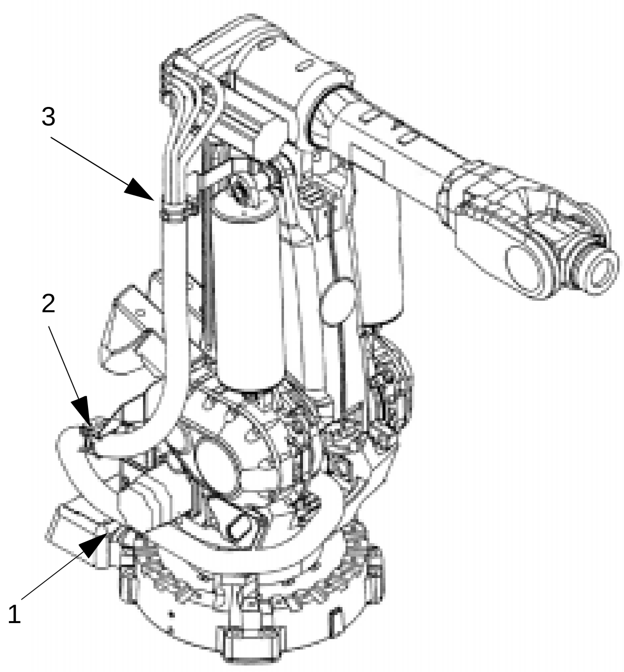


Figure 18 Location of snap attachments

Mounting:

8. Reassemble in the reverse order.

8.6 Fork Lift Device

Refer to foldout no 2:1.

Dismounting:

1. Attach a hoist to the lifting device <100>.
2. Loosen the screws <100.1> and washers <100.2>.

Mounting:

3. Mount in reverse order.

Tightening torque:

M16x60 screws	300 Nm

9 Calibration

9.1 General

The robot measurement system consists of one feedback unit for each axis and a measurement board that continuously keeps track of the current robot position. The measurement board memory has a battery backup.

Note! The accumulator unit will be fully recharged when the main supply has been on for 36 hrs. without any power interruptions.

The measurement system must be carefully calibrated (as described in Chapter 9.2, Calibration procedure) if any of the resolver values are changed. This happens when:

- parts affecting the calibration position have been replaced on the robot.

The system needs to be roughly calibrated (as described in Chapter 11.1, Setting the calibration marks on the manipulator) if the contents of the revolution counter memory are lost. This may happen when:

- the battery is discharged.
- a resolver error occurs.
- the signal between a resolver and measurement board is interrupted.
- a robot axis has been moved with the control system disconnected.

9.2 Calibration procedure

The calibration is performed with the DynaCal System (see Figure 19).

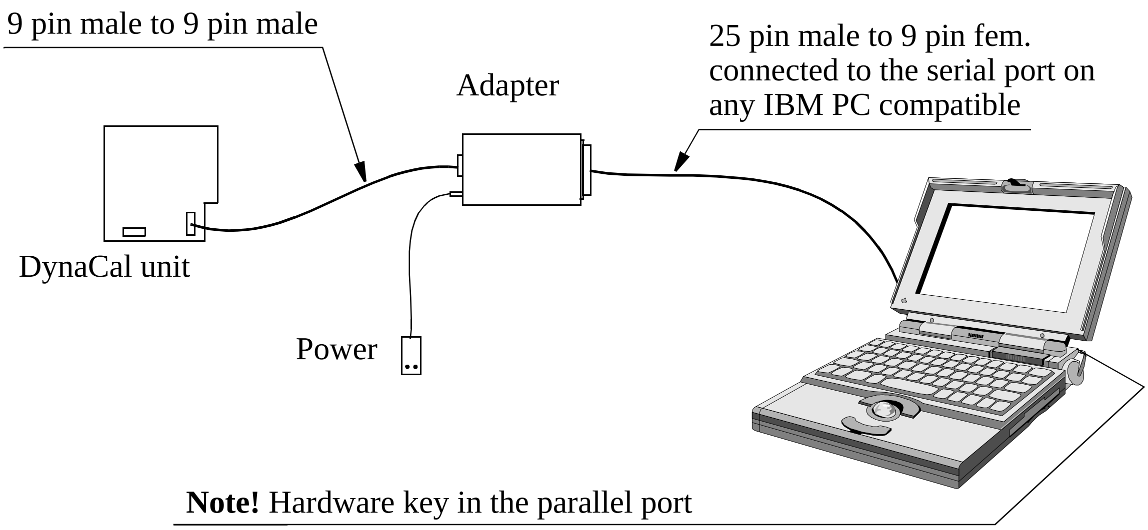


Figure 19 The DynaCal System.

System Requirements:

IBM PC with SVGA monitor and Windows 95/NT

How to calibrate one individual robot is described in this manual, for further information, please see DynaCal User's Manual, supplied with the DynaCal kit.

Note! To be able to utilize the DynaCal system for calibration of axis 1, the robot, at installation, must have been calibrated according to the DynaCal-method and the measuring program that was created is available on a diskette. The DynaCal calibration unit must then have been mounted on a location that can be utilized again, see DynaCal User's Manual.

If the method, described above, not have been carried out, axis 1 must be calibrated according to section 9.2.1.

If the robot at installation has been calibrated with the DynaCal system continue according to section 9.3.

9.2.1 Calibrating axis 1, without the DynaCal System

1. Position the manipulator approximately in calibration position 0.

2. Select the MOTORS OFF mode.

3. Remove the cover plate on the reference surface on gearbox 1.

4. Attach the synchronisation bracket 3HAC 4663-2 (1) and stop (2) to the flat surface and insert the corresponding measuring pin 6896 0011-YN (3) in one of the three holes in the base.
   Turn the operating mode selector to MANUAL REDUCED SPEED.

5. Operate the robot manually with the joystick until the measuring pin (3) is positioned within the flat surface of the stop (2).

Be careful! Risk of injury!

6. Align the pin and stop with the calibration tool. See Figure 20.

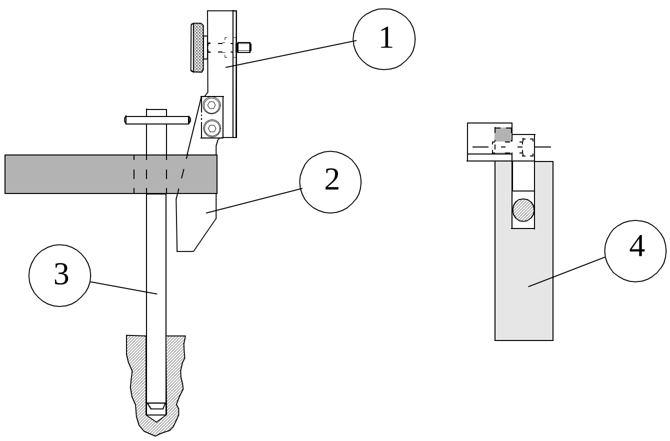


Figure 20 Aligning the pin and stop with the calibration tool for axis 1.

7. When the robot has been adjusted, the resolver value is stored by executing commands on the teach pendant according to 11.

For Calibration set and tool number, see 12 Special Tools List Calibration Equipment.

9.3 .Calibrating the robot with the DynaCal system

The measurement cable is the most fragile part of the system. So always be careful when manipulating it. Damaging the cable might compromise the overall accuracy of the system.

When transporting the DynaCal system, avoid hitting the calibration unit against other objects.

After every use, put both the DynaCal unit and the Adaptor back in the black case.

1. Mount the DynaCal Calibration unit inside the working range of the manipulator (see Figure 21 and Figure 22).

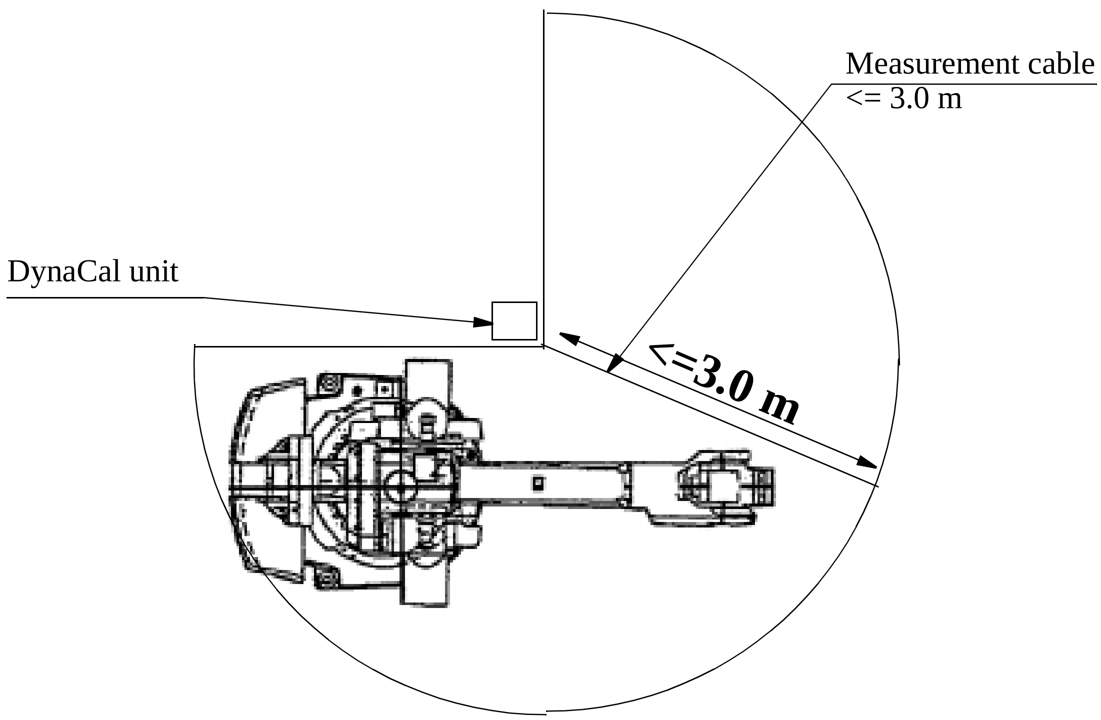


Figure 21 Location of DynaCal unit.

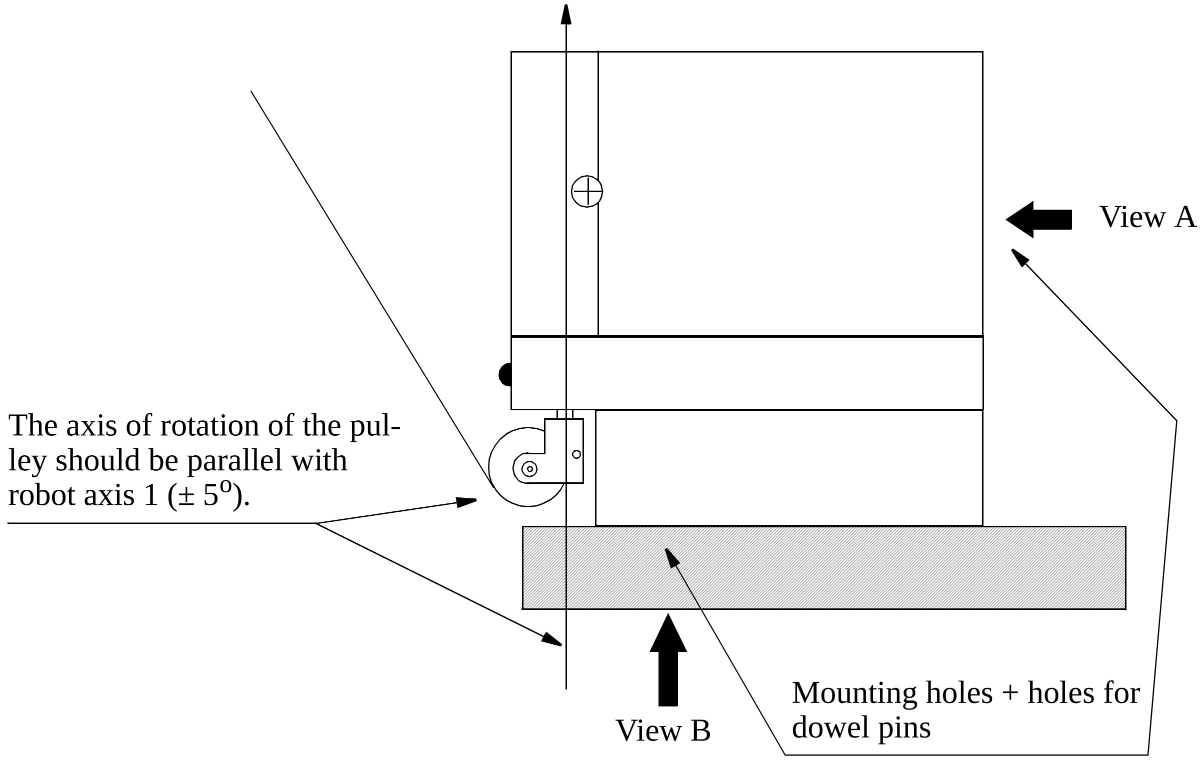


Figure 22 How to mount the unit.

2. Use either a c-clamp or a bracket in the holes prepared in the unit (see Figure 23).

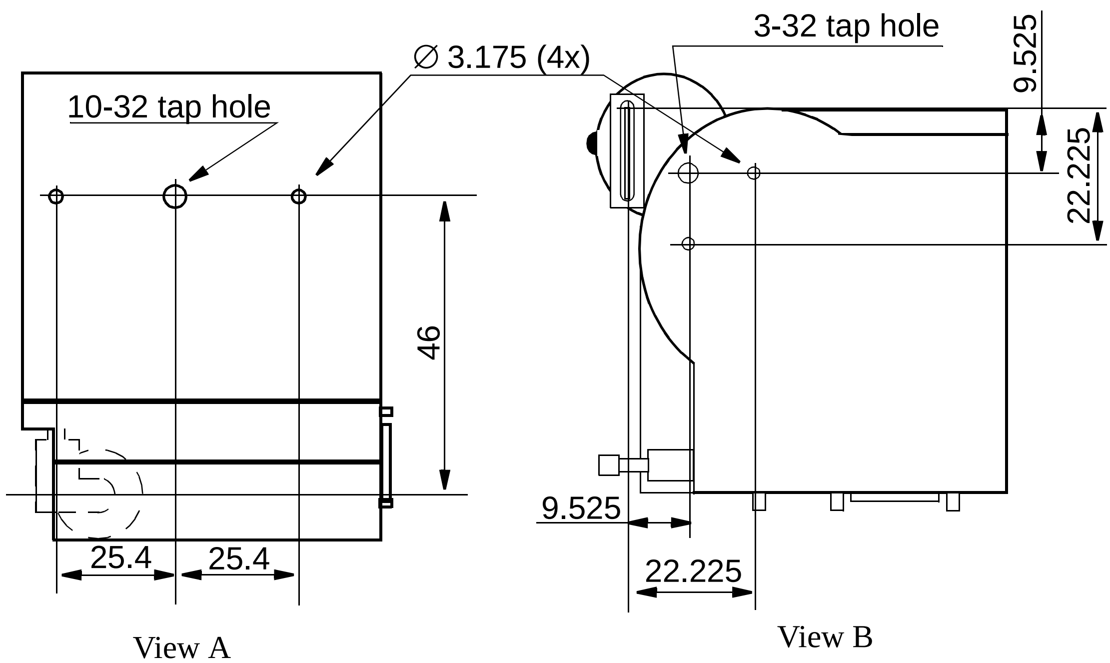


Figure 23 Mounting hole patterns on unit.

3. Hook up the system together with a PC according to Figure 19.

4. Mount the calibration tool, 3HAC 4083-1, onto the mounting flange of the robot as shown in Figure 24.
NOTE! The TCP value for the tool is written on the label on the tool.

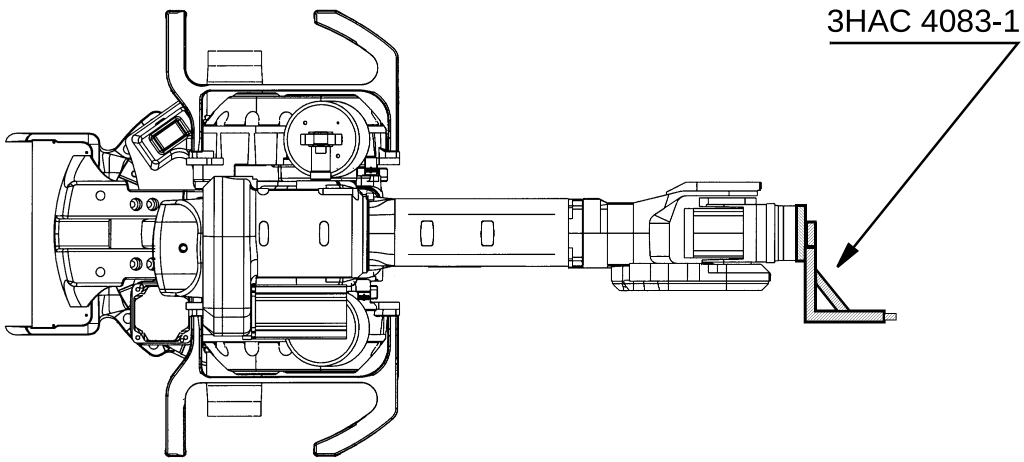


Figure 24 Tool 3HAC 4083-1 mounted on the mounting flange, robot in calibration position.

5. Mount the DynaCal calibration adapter onto the calibration tool.

6. Install the DynaCal™ System Software in the PC (two diskettes), see below:

   - Press the “**Start**” menu in Windows.
   - Select “**Run**”.
   - Enter **a:\setup”** and press **OK**.
   - Follow the instructions on screen.

7. Enter the TCP value for the tool (see point 4.), and activate it. Check that the TCP is correct by reorientating the wrist with the joy-stick.

8. Click on the “Start” button in Windows. Select “Programs”, and then select “DynaCal Calibration System Software” from the list of programs.

9. The menu shown on the screen is similar to all Windows products.

The DynaCal Software requires every robot to be associated to a project (i.e. every new robot to be calibrated has to have a new project associated with it).

10. To create a new project choose, **Project: New.**

11. In the window **“New Project”** enter a project name, the directory where the project is to be stored, also select the type of robot and the type of application the robot performs.

12. In the same window, click the **“Measurement option (DynaCal)...”** button and check that the **Configuration file (.clb)** has the same number as the serial number of the DynaCal Calibration unit (see sign on the unit).

13. Then click the button ***OK*** in the **“New Project”** window.

14. The **“Master Robot Project Screen”** appears with a picture of the manipulator.

15. To start the measurement procedure, click the **“Measure”** button.

16. A dialog box appears telling you to make sure that the measurement cable is at the reference position on the DynaCal Calibration unit.

Note! Make sure that the cable attachment is placed in the reference position to establish the zero point for the measurement process. Click *OK*.

17. Now the **“Measurement Screen”** window appears.

At this stage you should read a value of approx. 101.8. Pull the cable out and in a couple of times by hand and then place it in it’s reference position again and check that you have approx. the same value as from the beginning.

18. Now position the hook on the measurement cable onto the calibration adaptor (mounted on the calibration tool). Make sure that the hook is properly engaged.

The calibration positions of the robot are done, using the teach pendant. Move the robot to each position and store the position. Before moving the robot again you also teach the measurement point by clicking the **“Measure”** button in the **“Measuring Screen”**.

The number of positions should be between 20 -30. The calibration positions should cause as much change as possible in the tool orientation, and the robot should move to its extremes (minimum reach and maximum reach). For convenience you may select positions in a 1x1x1 m cube. Note that the angle at the joint coupling of the calibration adapter at the end of the cable should not exceed 90 degrees.

19. Move the robot to the first position and store the position in the robot program. Make sure that you have the right TCP activated.

20. At this position, also measure the point by clicking the **“Measure”** button or using the “M” key of the keyboard. Make sure that the cable itself is not in contact with any part of the robot or the fixtures present in the cell.

21. Continue in the same way with all of the other positions.

22. After the last position, place the cable in its reference position.

23. The default name for the measurement position file is DynaCal/1.msr (the name can be changed by typing a new file name).

24. Then click ***OK*** in the **“Measurement Screen”** window.

25. A **“Measurement Complete”** message appears.

26. The measurement file will show up in the **“Measurement files”** box of the project window.

27. Copy the robot program with the 20-30 positions to a diskette as a module.
File: “Save Module as”.

28. Insert the diskette into the PC.

29. Enter the file by selecting **Project: Add Files To Project.**

30. Select the file in the **"Insert file(s) into Project"** dialog window and click ***Open***.

31. The file will now appear in the **"Robot Files"** box in the project window.

32. Click the file (obtained from the robot) in the **"Robot Files"** box.

33. Drag the file to the **"Measurement file"** box. While holding the file upon the measurement file, press the Shift key. Now release the left mouse button (which you initially pressed to drag the file).

34. The **"Choose Calibration System"** window appears.

35. Open the pop-up menu for **"Parameter File"** and select the right robot type, click ***Open***.

36. Then click ***OK*** in the **"Choose calibration system"** dialog box.

37. A box called **"Parameters for: (name of robot program).mod"**. Check that the TCP information are correct. If not enter the correct TCP values. Click ***OK***.

38. Click the ***"Robot"*** button in the window **"Calibrate"**.

39. Check that the box "Nominal" is selected, than click ***OK***.

40. Start the calibration by clicking the button **"Start calibration".**

41. Now click the button ***"Remove worst point and Recalibrate"*** a couple of times. The figures in "Calibration results" should not change so much after pressing the button a couple of times.

42. Then click the button **"Save calibration & Close"**.

43. A box called **"DynaCal"** appears. Click ***"Yes"***.

44. Then just click ***"Save"*** in the box **"Save as"**.

45. Click ***"Yes"*** if you get a question if you want to replace the already existing file.

46. Now a file called ***"FineSync.mod"*** appears in the box **"Robot files"**.

47. Right-click on the file and choose **"Send File(s) To A\:"**.

48. Delete existing main routine in the robot system.

49. Load the **FineSync. mod** program into the robot system and run the program.

50. Store the new values according to section 11.

10 Onboard Calibration

10.1 General

Onboard Calibration is used to allow short service breaks to check and if necessary recalibrate the measurement system after e.g. collisions or tool jams, or after a replacement of a motor on axes 1-4.

In case of a bigger operations e.g. change of structure parts or the wrist the robot have to be calibrated with the “Field DynaCal” equipment see 9.3and followed by a new Onboard Calibration to update new sensor position angles.

The sensor position is measured for all axes and stored on a floppy disk and in the system parameters, and before delivery from SEROP they are printed on a label.

The sensor positions are measured with 0 kg load before shipment from SEROP.

When checking the calibration position with a load (tool), the Onboard Calibration have to be performed with the same load as in the original measurement, and during installation new sensor positions should be measured and stored when the load (tool) is mounted.

If unacceptable deviations in the measurement system is discovered during Onboard calibration, enter the old calibration offset into the program, and a new correct calibration offset will be displayed.

The Onboard calibration equipment contains four sensors mounted on the manipulator axes 1-4, one calibration tool with two mounted sensors for axes 5 and 6, one I/O connection box with six sensor cables (L = 5 m), one CANBUS cable with Phoenix connector (L 15 m) one CANBUS cable (L 6 m) and one Tap connector (3 way connector).

The Onboard calibration kit have to be ordered from ABB and is delivered in a box.

Please order from ABB Robotics Dpt. SEROP/S.

10.2 Setup Onboard Calibration Equipment

The calibration is performed with the stationary sensors on axes 1 to 4, for axes 5 and 6 a tool is mounted when it is time for calibration.

Note ! During installation of the system, add the config file eio_obc.cfg to the system parameters.

The system must be powered off during installation off the Onboard Calibration equipment.

With CANBUS (See Figure 25 Connection with CANBUS)

1. Dismount the customer CANBUS cable from the R2.CANBUS connector on the upper arm or on axis 4 housing.

2. Mount the Tap (3 way connector) to the connector R2.CANBUS and the 6 m cable from the Tap to the I/O box.

3. Reconnect the customer CANBUS cable to the Tap.

Note ! The terminating resistor switch on the I/O box should be turned OFF.

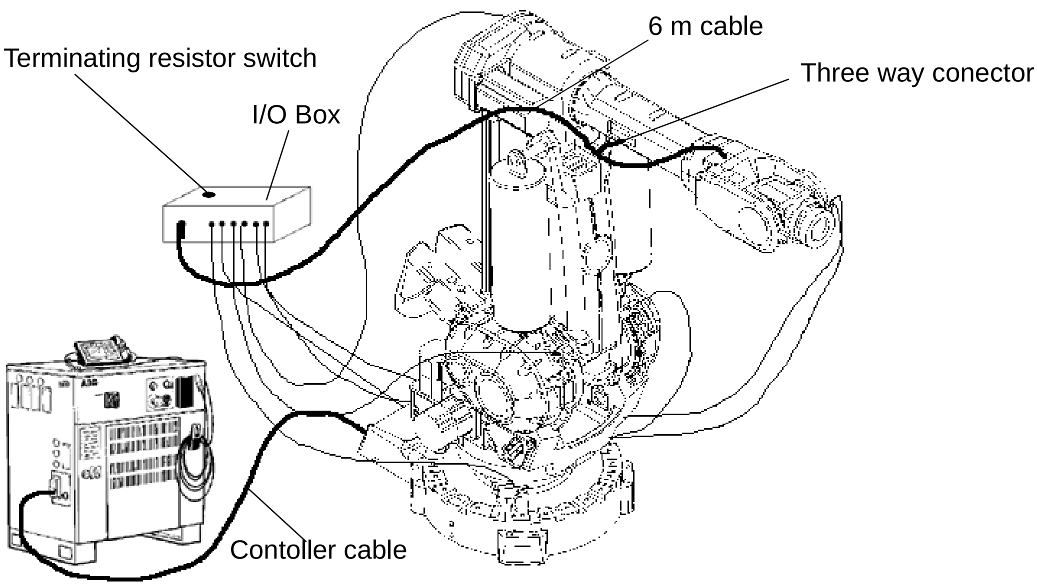


Figure 25 Connection with CANBUS

Without CANBUS (See Figure 26 Connection without CANBUS)

4. Connect the 15 m cable from the I/O box to the connector X10 on the backplane of the controler.

Note ! the terminating resistor switch on the I/O box should be turned ON.

5. Restart the system and load the program (see 10.3 Load the program on_board.prg. load program).

6. Remove the calibration plate and cover on motor axis 6.

7. Remove the cover axis 4.

8. Attach the tool for calibration on axes 5 and 6.

9. Remove the protective cap from the sensors on axes 1-4.

10. Connect the cables from the box to the sensors on axes 1-6 see Figure 25 Connection with CANBUS.

During Onboard calibration will the robot or the axes that is going to be calibrated move towards the sensor (target) position.

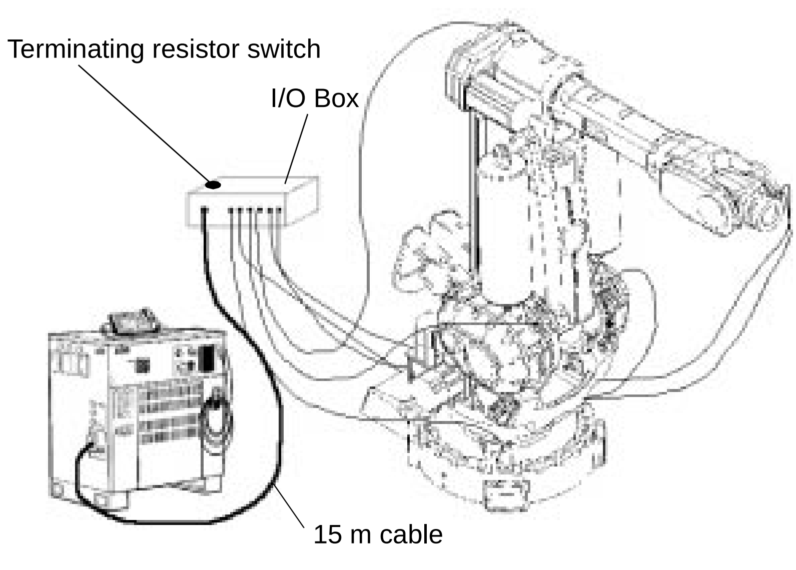


Figure 26 Connection without CANBUS

10.3 Load the program on_board.prg.

- Press the Program key to open the window.
- Choose **File: Open**.

A dialog box appears, displaying all programs in the current directory (see Figure 27).

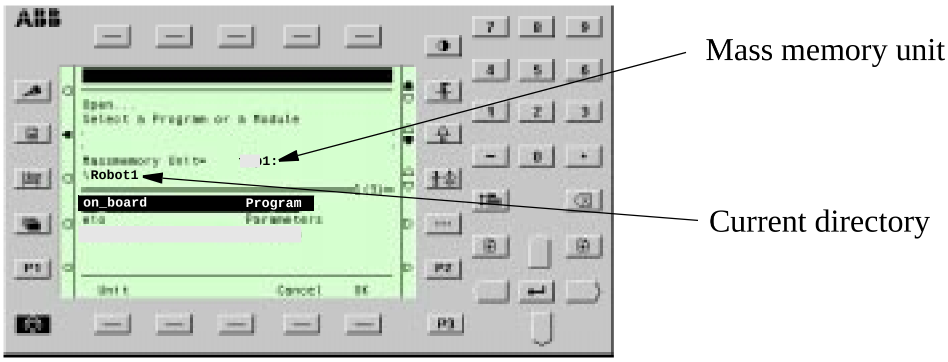


Figure 27 The dialog box used to read programs.

- If necessary, change the mass memory unit by pressing ***Unit*** until the correct unit is displayed.
- Select the desired program. Move up or down in the directory by using either ‘. .’ (up), or the desired directory (down) and press Enter .
- Choose ***OK*** to confirm.

When a program is already loaded into the system, but has not been saved, and you wish to open another program, a dialog box appears and you will be asked whether you want to save the old program or not.

1. Remove the calibration plate and cover on motor axis 6.
2. Remove the cover axis 4.
3. Attach the tool for calibration on axes 5 and 6.
4. Remove the protective cap from the sensors on axes 1-4.
5. Connect the cables from the box to the sensors on axes 1-6 see Figure 25 Connection with CANBUS.
6. During Onboard calibration will the robot or the axes that is going to be calibrated move towards the sensor (target) position.

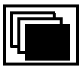
Sensor Positions.

Axis	1	2	3	4	5	6
Angle	-8,4°	-7,5°	+18,0°	-4,0°	-15,0°	±0°

10.4 Check of Measurement System/Calibration

Read and note the sensor positions (cal_sensor_positions) and calibration offset (cal_offset) values from system parameters for the axes to be tested, if only the calibration position is going to be tested is only the sensor positions needed.

To read and note the cal_sensor_position and cal_ offset.

- Press the Miscellaneous key  and select the Service Window.
- Select System parameters-Manipulator-Type1-Motor-Calib.

If the measurementsystem, of some reason got large deviations from delivered calibration on some or all axes, then the axes have to be course calibrated before program start, use the calibrations plates to adjust the axes.

Do not recalibrate axes with correct calibration offset.

If a new update of the calibration offset has been done, always make a course check of the new calibration offset by jogging the axis to the sync. plates and read the position value from the teach pendant window, (position shall be close to 0,0 degrees).

Note! that the values in the following figures are not correct, the figures are only examples for the displayed windows during Onboard calibration.

Program Start

Start program

- Press the function key ***continue*** to run the calibration program.

Default Load Values

The default load value is used only for the movement of the robot during the calibration, it will not affect the onboard calibration function it self.

If the default values are used.

- Press the function key ***Yes*** and continue to Select All Axes or One by One

If the default values not are used.

- Press the function key ***No*** and continue to Load Values

The default Load value is 100 kg and center of gravity values is x=0, y=353 mm z=353 mm.

Load Values

Enter Load values

- Enter a value in kg and press the function key ***OK.***

Center of Gravity

Enter a value for center of gravity.

- choose a value for x,y and z axes and press the function key ***OK***.

Select All Axes or One by One

Calibrate the axes one by one or all at the same time.

To calibrate all axes.

- Press the function key ***All axes.***

The robot moves to the start position for all axes, (sensor positions) then the system measures one axis at a time.

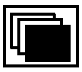
- Press the function key ***One axis*** to calibrate the axes one by one, continue to chapter Test the axes One by One .

Sensor Positions

The sensor positions for all axes are measured and displayed.

- Press the function key ***continue*** to enter old sensor positions.

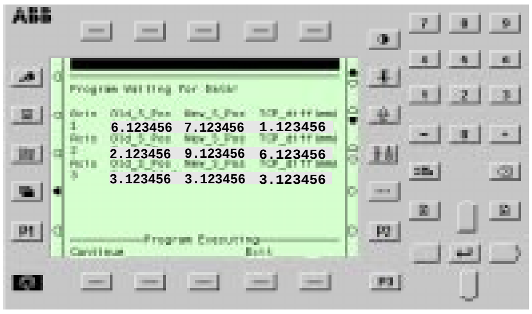
When calibrating the sensor positions at installation with customer load mounted, note the sensor position values, and after program finished the values are feed into the system parameters.

- Press the Misc. key  .
- Sellect the Service Window
- Sellect System parameters-Manipulator-Type1-Motor-Calib-cal_sensor-position.
- Enter value
- Restart system.

Displayed Calculated Position Difference

After entering the old sensor positions, the difference between the new and old positions on axes1 - 3 are displayed.

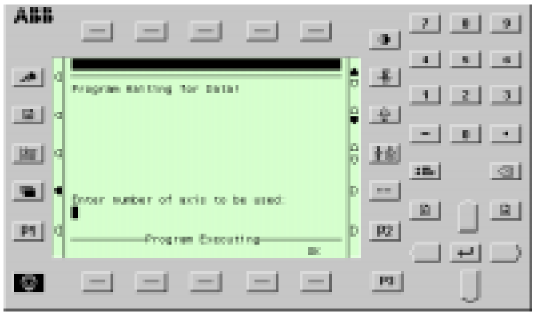
- Press the function key ***continue*** to view positions for axes 4 - 6.
- Press the function key ***Exit*** and the test is finished.



Test the axes One by One

When the axes is to be tested one by one, chose one axis see Select All Axes or One by One.

- Select the axis to be measured.
- Press the function key ***OK.***



A window appear that says Robot starts moving. (only the axis to be measured will be moved to its sensor position).

- Press the function key ***continue.***

Old Sensor Positions

When the measuring of current axis is done, enter the old sensor position for the current axis.

- Press function key ***OK.***

Calculate the new cal. offset value

The difference between old and new sensor pos. is now displayed.

If you want to calculate the new cal. offset value, enter the old calibration offset value.

- Press function key ***Yes***.

or if you want to exit the calib.program.

- Press function key ***Exit.***

New Active Calibration Offset

The new calibration offset value is displayed.

If you want to measure more axes.

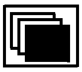
- Press the function key ***Yes.***

If you want to exit.

- Press the function key ***No.***

10.4.1 Load Calibration Offset Value

The new calibration offset value is manualy loaded into the system parameters by this operation.

- Press the Miscellaneous key  and select the Service Window.
- Select System parameters-Manipulator-Type1-Motor-Calib.
- Enter value.
- Restart system.
- Save the new calibration offset value on the parameter disk and write the value down on the lable.

11 Storing the values on the teach pendant

1. Press the **Misc.** window key (see Figure 28).

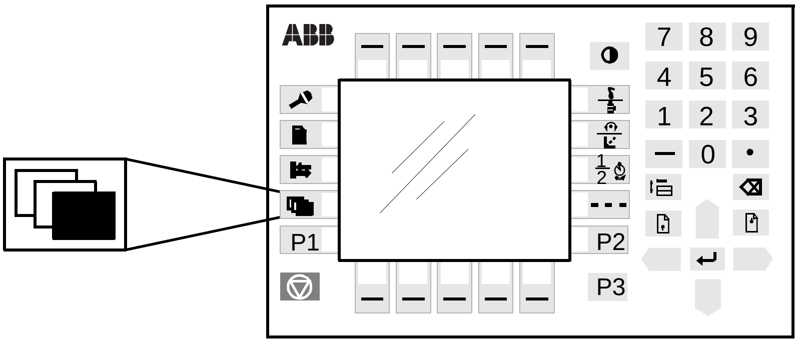


Figure 28 The Misc. window key from which the Service window can be selected

2. Select **Service** in the dialog box shown on the display.
3. Press **Enter** .
4. Select **View: Calibration**. The window in Figure 29 appears.

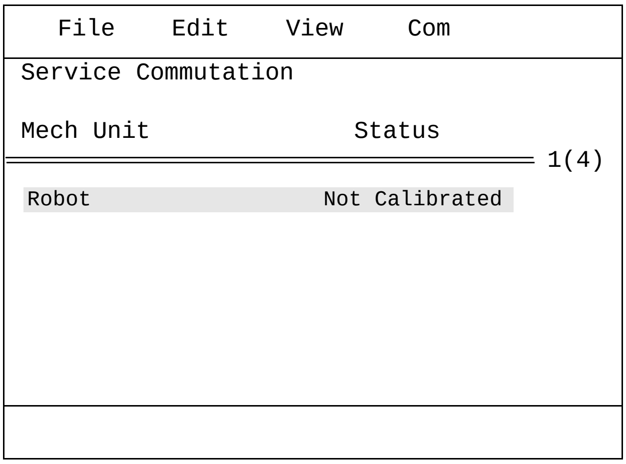


Figure 29 The window shows whether or not the robot system units are calibrated.

The calibration status can be any of the following:

- **Synchronized**
  All axes are calibrated and their positions are known. The unit is ready for use.
- **Not updated Rev. Counter**
  All axes are fine-calibrated but one (or more) of the axes has a counter that is NOT updated. That axis, or those axes, must therefore be updated as described in Chapter 11.1, Setting the calibration marks on the manipulator.
- **Not calibrated**
  One (or more) of the axes is NOT fine-calibrated. That, axis or those axes, must therefore be fine-calibrated as described in Chapter 9.2, Calibration pro-

cedure.

5. If there is more than one unit, select the desired unit in the window in Figure 29. Choose **Calib: Calibrate** and the window shown in Figure 30 will appear.

```
Calibration!
Robot
To calibrate, include axes and press OK.

     Axis              Status
                                            1(6)
X      1          Not Fine Calibrated
X      2          Not Fine Calibrated
       3              Fine Calibrated
       4              Fine Calibrated
X      5          Not Fine Calibrated
X      6          Not Fine Calibrated

   Incl     All           Cancel    OK
```

Figure 30 The dialog box used to calibrate the manipulator.

6. Press the function key ***All*** to select all axes, if all axes are to be commutated. Otherwise, select the desired axis and press the function key ***Incl*** (the selected axis is marked with an x).

7. Confirm by pressing ***OK***. The window in Figure 31 appears.

```
Calibration!
Robot

     - - - - - WARNING - - - - -
The calibration for all marked axes
will be changed.

It cannot be undone.
OK to continue?



                         Cancel    OK
```

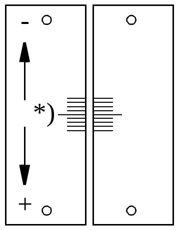
Figure 31 The dialog box used to start the calibration.

8. Start the calibration by pressing ***OK***.

An alert box is displayed during calibration.
The Status window appears when the fine calibration is complete. The revolution counters are always updated at the same time as the calibration is performed.

Calibration plate and calibration marks

9. Adjust the calibration plates for axes 1-6 (see Figure 32).



*) axis number

Figure 32 Calibration marking.

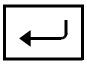
10. Check the calibration position as described in Chapter 11.2, Checking the calibration position.

11. Change to the new calibration offset on the label, located **?????**. The new calibration offset values can be found as follows:

    • Select the window SYSTEM PARAMETERS;

    • **Types: Motor**;

    • Select axes in question;

    • Press Enter 

    • Note the Cal offset value.

12. Save system parameters on a floppy disk.

11.1 Setting the calibration marks on the manipulator

When starting up a new robot, you may receive a message telling you that the manipulator is not synchronised. The message appears in the form of an error code on the teach pendant. If you receive such a message, the revolution counter of the manipulator must be updated using the calibration marks on the manipulator. See Figure 32.

Examples of when the revolution counter must be updated:

- when the battery unit is discharged
- when there has been a resolver error
- when the signal between the resolver and the measuring system board has been interrupted
- when one of the manipulator axes has been manually moved without the controller being connected.

It takes 36 hours' operation to recharge the battery unit without any power interruptions.

If the resolver values must be calibrated, this should be done as described in the chapter on Repairs in the IRB 6400 Product Manual.

WARNING
Working in the robot work cell is dangerous.

Press the enabling device on the teach pendant and, using the joystick, move the robot manually so that the calibration marks lie within the tolerance zone (see Figure 37). N.B. Axes 5 and 6 must be positioned together.

Note that axis 6 does not have any mechanical stop and can thus be calibrated at the wrong faceplate revolution. Do not operate axes 5 and 6 manually before the robot has been calibrated.

When all axes have been positioned as above, the values of the revolution counter can be stored by entering the following commands on the teach pendant:

1. Press the **Misc.** window key (see Figure 33).

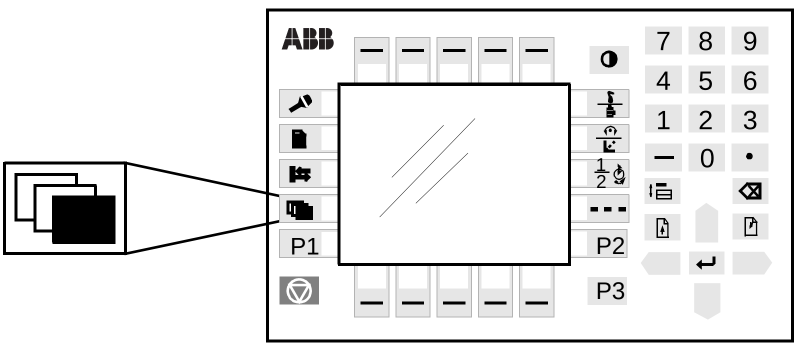
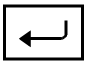


Figure 33 The Misc. window key from which the Service window can be selected

2. Select **Service** in the dialog box shown on the display.

3. Press Enter  .

4. Then, choose **View: Calibration**. The window shown in Figure 34 appears.

```
   File     Edit     View    Calib
 Service Calibration

 Mech Unit                 Status
                                          1(4)
 Robot                        Unsynchronized
```

Figure 34 This window shows whether or not the robot system units are calibrated.

5. Select the desired unit in the window, as shown in Figure 34.
Choose **Calib: Rev. Counter Update**. The window in Figure 35 appears.

```
 Rev. Counter Updating!
 Robot
 To update, include axes and press OK.

      Axis                 Status
                                          1(6)
 X      1       Not updated Rev. Counter
 X      2       Not updated Rev. Counter
        3       Calibrated
        4       Calibrated
 X      5       Not updated Rev. Counter
 X      6       Not updated Rev. Counter

    Incl     All             Cancel    OK
```

Figure 35 The dialog box used to select axes whose revolution counter is to be updated.

6. Press the function key ***All*** to select all axes, if all axes are to be updated. Otherwise, select the desired axis and press the function key ***Incl*** (the selected axis is marked with an x).

7. Confirm by pressing ***OK***. A window like the one in Figure 36 appears.

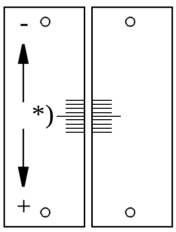
```
Rev. Counter Updating!
Robot

The Rev. Counter for all marked axes
will be changed.

It cannot be undone.
OK to continue?

                           Cancel    OK
```

Figure 36 The dialog box used to start updating the revolution counter.

8. Start the update by pressing ***OK***.

If a revolution counter is incorrectly updated, it will cause incorrect positioning. Thus, check the calibration very carefully after each update. Incorrect updating can damage the robot system or injure someone.

9. Check the calibration as in Chapter 11.2, Checking the calibration position.



*) axis number

Figure 37 Calibration marks on the manipulator.

10. Save system parameters on a floppy disk.

11.2 Checking the calibration position

There are two ways to check the calibration position; both are described below.

Using the diskette, Controller Parameters:

Run the program \ SERVICE \ CALIBRAT \ CAL 6400 on the diskette, follow instructions displayed on the teach pendant. When the robot stops, switch to MOTORS OFF. Check that the calibration marks for each axis are at the same level, see Figure 37. If they are not, the setting of the revolution counters must be repeated.

Using the Jogging window on the teach pendant:

Open the Jogging window  and choose running axis-by-axis. Using the joystick, move the robot so that the read-out of the positions is equal to zero. Check that the calibration marks for each axis are at the same level, see Figure 37. If they are not, the setting of the revolution counters must be repeated.

11.3 Alternative calibration positions

Before it can be calibrated in one of the two alternative positions, the robot must have been calibrated with calibration equipment at calibration position 0 for all axes (the robot is delivered with calibration position 0). See Figure 38.

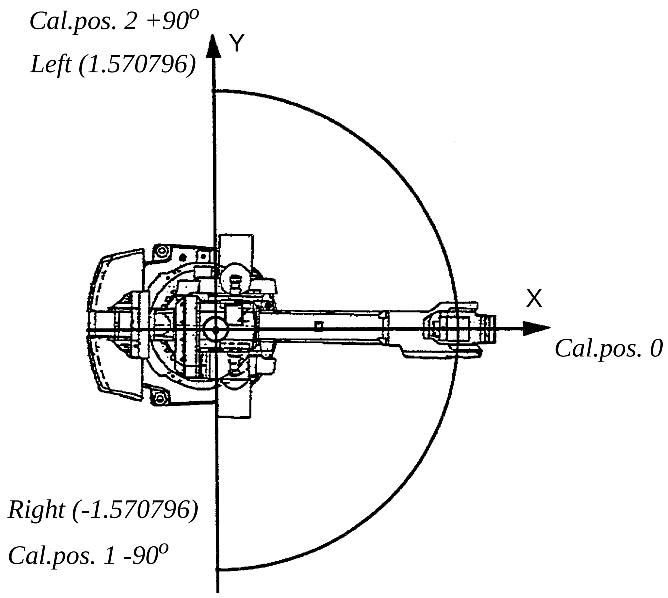


Figure 38 Calibration positions 0, 1 and 2 (Normal, Right and Left)

Note!
If the final installation makes it impossible to reach the calibration 0 position, an alternative calibration position must be set before installation.

1. Run the calibration program CAL64 M96 on system disk Controller Parameter (SERVICE.DIR\ CALIBRATE.DIR). Select Normal position, check the calibration marks for each axes.

2. Run the calibration program again and select the desired calibration position (Left or Right), see Figure 38.

3. Change to the new calibration offset for axis 1, as follows:

   - Select the window SERVICE;
   - **View: Calibration**;
   - **Calib: Calibrate**;
   - Select axis 1 (no other axes)
   - Then confirm by pressing ***OK*** two times.

4. Change to the new calibration offset on the label, located on the frame to the left of motor axis 1 (remove the cover between axes 2 and 3). The new calibration offset values can be found as follows:

   - Select the window SYSTEM PARAMETERS;
   - **Types: Motor**;
   - Select axis 1;
   - Press Enter ↵
   - Note the Cal offset value.

5. Change to the new calibration position on axis 1, as follows:

   - Select the window SYSTEM PARAMETERS;
   - **Topics: Manipulator**;
   - **Types: Arm**;
   - Select axis 1;
   - Change Cal pos to 1.570796 or -1.570796 depending on selected calibration position. The angle is in radians, see Figure 38.

6. Restart the robot by selecting **File: Restart**.

7. Move the sync.plate, on the base, for axis 1 to its new position.

8. Save the system parameters on a floppy disk.

For Calibration equipment see Running H/F 2 Repairs

12 Special Tools List

All sections e.g **Motor Axes 1-3** refers to sections in chapter 12 Repairs.

The need for special tools has been reduced to a minimum. When tools are needed for dismounting/mounting work, a description is given in the Product Manual, Chapter Repairs.
During the ordinary service training courses arranged by ABB Flexible Automation, detailed descriptions of the tools are given together with their use.

Motors Axes 1-3	**Rem.**
Lifting Device Axis 1	3HAC6875-1
Lifting Device Axes 2-3	3HAC 6876-1
Pinion Press	3HAC 4850-1
Dismount Pinion	SKF Oil injector 226 270
“	SKF Nipple 101 82 19
Motors/Gears Axes 4-6	**Rem.**
Pump	6369 901-286
Dismounting, gear motor axis 4	SKF oil injector 226 270*
Pressing tool, gear on motor axis 4	6896 134-AC
Pressing tool, final gear	6896 134-AT/-AN
Valve	SKF 234 063
Hydraulic cylinder	NIKE I-CH 612*
Holding tool, tube shaft end	6896 134-BU*
Holding tool, final gear	6896 134-FK*
Pressing tool, tube shaft	3HAB 8079-1
Pressing tool, front bearing, tube shaft	6896 134-S
Pressing tool, housing and rear bearing	6896 134-FL
Pressing tool, seal inside housing	6896 134-FA
Dismounting rear bearing and housing, axis 4	6896 0011-YJ
Puller gear motor axis 6	3HAA 7601-043
Play measurement tool, wrist	6896 134-CE
Play measurement tool, wrist	6896 134-CD

Play measurement tool, wrist	6896 134-CF
Balancing Cylinders	**Rem.**
Auxiliary shaft Bearing Race	3HAB 5281-1
Auxiliary shaft	3HAB 5276-1
Auxiliary shaft	3HAB 5275-1
Screw	M12x40
Lifting Device	3HAC 6877-1
Lubricating tool	3HAC 5222-1
Arm System	**Rem.**
Measurement fixture, gear motor shaft axis 5	6896 134-GN*
Pressing tool	3HAC 5025-1
Lifting device Upper Arm	3HAC 1817-1
KM 12 Socket	3HAC 5347-1
Mouting tool - Lower Arm	3HAC 5216-1
Demounting tool - Lower Arm	3HAC 5302-1
Tightening tool	3HAB 1022-1
Mounting/Demounting tool - Parallel Bar	3HAC 5021-1
Mounting tool Roller Bearing/Sealing Complete.	3HAC 2246-1
Mounting tool Roller Bearing/Sealing (Front)	3HAC 1893-1
Mounting tool Roller Bearing/Sealing (Back)	3HAC 1894-1

Calibration tool for TCP check	**Rem.**
Tool for TCP adjustment	3HAA 0001-UA X=-15 mm, Z=-150 mm
Calibration set for Vision	3HAA 0001-XR
Bracket	

Calibration tools axis 1

Sync. fixture set	3HAC 6355-1
Bracket	3HAC 4663-2
Stop	3HAC 4691-1
Measure pin	6896 0011 YN
Calibration tool	3HAB 7477-1

Calibration tools axis 2-6 (1)

DynaCal equipment	
Calibration tool	3HAC 4083-1

Onboard calibration tools

OnBoard Calib. Set Complete	3HAC 6809-1
I/O Box with sensors and sensor cables	3HAC 7006-1
Calibration tool for axis five and six.	3HAC 6004-1
Documentation, Onboard User’s Guide	3HAC 8063-1

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1 Rebuilding Parts

Following chapters **(1.1-1.5)** describes the main details that differ from the basic version **IRB 6400R / 2,5-150.**

Note ! This list is valid for rebuilding to a standard IRB, Options like Foundry or insulated mounting flange are not included.

1.1 IRB 6400R / 2.5-120

Foldout 1:1

Item	Qty	Article No	Name of Item	Rem.
1	1	3HAC 3599-1	Motor Axis 3	

1.2 IRB 6400R / 2.5-200

Foldout 1:1

Item	Qty	Article No	Name of Item	Rem.
2	1	3HAC 3602-1	Motor Axis 2	
3	1	?	Upper arm complete	
4	1	3HAC 4103-1	Balancing weight 309 kg	

1.3 IRB 6400R / 2,8-150

Foldout 1:2

Item	Qty	Article No	Name of Item	Rem.
1	1	3HAC 5441-1	Arm extension set	
2	1	3HAC 4327-1	Harness axis 5, 680	
3	1	3HAC 4328-1	Harness axis 6, 790	
4	1	3HAC 4103-1	Balancing weight 309 kg	
5	1	3HAC 4547-1	Cover	

1.4 IRB 6400R / 2,8-200

Foldout 1:2

Item	Qty	Article No	Name of Item	Rem.
6	1	3HAC 3602-1	Motor Axis 2	
4	1	?	Upper arm complete	
7	1	3HAC 4129-1	Balancing weight 458 kg	

1.5 IRB 6400R / 3,0-100

Foldout 1:2

Item	Qty	Article No	Name of Item	Rem.
8	1	3HAC 3599-1	Motor Axis 3	
1	1	3HAC 3964-1	Arm Extension	
2	1	3HAC 4327-1	Harness axis 5, 680	
3	1	3HAC 4328-1	Harness axis 6, 1340	
4	1	3HAC 4103-1	Balancing weight 309 kg	

2 Part List Manipulator

Item number refers to item number on foldouts

(**Spare part no.** = See Spare Parts List Manipulator for the Spare Part number)

2.1 Manipulator IRB 6400R

Article No	Name	Foldout No
3HAC 3972-1	**Part List**	**2:1 - 2:3**

Item	Qty	Article No	Name of Item	Dimensions	Rem.
1	1	3HAC 4644-1	Axis 1-3 complete		
2	1	3HAC 3973-1	Upper arm complete		
3	1	3HAC 4671-1	Parallel bar incl bearing		**Spare part no.**
4	2	3HAC 3608-1	Balance unit type A		**Spare part no.**
4	2	3HAC 4219-1	Balance unit type B		**Spare part no.**
5	1	3HAC 3902-1	Balancing weight 154 kg		**Spare part no.**
5	1	3HAC 4103-1	Balancing weight 309 kg		**Spare part no.**
5	1	3HAC 4129-1	Balancing weight 458 kg		**Spare part no.**
6	1	3HAC 4724-1	Labels- and plate set		
7	1	3HAC 4807-1	Cover axis 4		
8	1	3HAB 7070-1	Cover		**Spare part no.**
9	1	3HAC 4349-1	Cover		
10	2	3HAA 1001-164	Protective plate		
11	30	3HAB 3537-1	Bearing grease		
12	1	3HAC 4807-3	Bracket, cover ax. 4		
13	1	3HAC 4547-1	Cover		**Spare part no.**
13	1	3HAC 4674-1	Cover,345		**Spare part no.**
13	1	3HAC 4675-1	Cover,550		**Spare part no.**
14	1	3HAC 4731-10	Welding Connector Lid		
15	3	3HAC 4836-2	Protection plug		
16	1	3HAC 4836-2	Protection plug		
17	1	3HAC 4836-6	Protection plug		

Item	Qty	Article No	Name of Item	Dimensions	Rem.
18	1	3HAC 5280-1	Cover, R1.CP/CS		
100	1	3HAC 4765-1	Fork lift set		
100.1	8	3HAB 3469-86	Hex socket head cap screw	M16x60	
100.2	8	3HAA 1001-186	Washer		
101	1	3HAC 4656-1	Mech stop 15 degr set ax1		
101	1	3HAC 4657-1	Mech stop 7,5 deg set ax1		
102	1	3HAC 4658-1	Mech stop ax 2/3 set		
103	1	3HAC 4658-1	Mech stop ax 2/3 set		
104	1	3HAC 4370-1	Connection box CANBUS		
104	1	3HAC 4371-1	Connection box IBUS/PBUS		
108	1	3HAC 3495-1	Harness CP/CS ax4		
108	1	3HAC 3494-1	Harness CP/CS ax3		
110	1	3HAC 3496-1	SWeld Harness 25/3 int.		
117	1	3HAC 4804-1	Signal Lamp		
118	1	3HAC 4702-1	Pos SW ax1 compl 1 funct.		
118	1	3HAC 4702-3	Pos SW ax1 compl 3 funct.		
118	1	3HAC 4702-2	Pos SW ax1 compl 2 funct.		
119	1	3HAC 4716-1	Pos SW ax 2 compl		
120	1	3HAC 4723-1	Pos SW ax 3 compl		
121	1	3HAC 4811-1	Fan axis 1 compl		
122	1	3HAC 4813-1	Cover, push button guard		
123	1	3HAC 6360-1	Onboard calibration		
200	2	3HAC 4545-1	Shaft		
201	2	9ADA 205-75	Set screw, cup point	M10x20	
202	1	3HAA 1001-125	Spacer		
203	2	2216 264-16	Sealing ring IRB 3000		
204	2	3HAA 1001-173	Sealing Ring		
205	2	2213 3802-8	Taper roller bearing	65x100x23	
206	2	2216 0085-5	Nilos ring	65x98,4x6,3	
207	2	3HAB 4460-1	Protective ring		
207	2	3HAA 1001-126	Spacer		
208	2	2126 2851-112	Lock nut	M60x2	
209	2	1269 0014-429	Locking liquid		

Item	Qty	Article No	Name of Item	Dimensions	Rem.
211	2	3HAA 1001-658	O-RING		
212	2	3HAB 3772-17	O-ring	53,34x5,34	
220	2	3HAC 4330-1	Shaft		
221	2	3HAC 4331-1	Thrust washer		
222	2	3HAC 4332-1	Cover washer		
223	2	9ADA 312-6	Plain washer	6,4x12x1,6	
224	2	9ADA 629-56	Torx pan head roll. screw	M6x116	
230	4	3HAC 3484-1	RING		
231	8	3HAC 3478-1	SUPPORT WASHER		
232	8	3HAC 3479-1	Sealing ring		
233	4	3HAC 3483-1	LOCK NUT		
240	4	3HAB 3409-93	Hex socket head cap screw	M16x120	
241	4	3HAA 1001-186	WASHER		
251	1	3HAC 4756-1	Holder for cableguide		
252	1	3HAC 4757-1	Cableguide		
253	8	9ADA 629-56	Torx pan head roll. screw	M6x16	
254	5	9ADA 312-6	Plain washer	6,4x12x1,6	
260	2	9ADA 624-56	Torx counters. head screw	M6x16	
261	12	9ADA 629-56	Torx pan head roll. screw	M6x16	
262	4	9ADA 629-55	Torx pan head roll. screw	M6x16	
263	2	9ADA 629-55	Torx pan head roll. screw	M6x16	
264	2	9ADA 629-55	Torx pan head roll. screw	M6x16	
265	4	9ADA 629-55	Torx pan head roll. screw	M6x16	
266	19	9ADA 629-55	Torx pan head roll. screw	M6x16	
267	23	9ADA 629-55	Torx pan head roll. screw	M6x16	
268	25	9ADA 629-55	Torx pan head roll. screw	M6x16	
269	1	9ADA 629-57	Torx pan head roll. screw	M6x20	
600	1	3HAC 2763-1	UL-label	70x35	
601	1	3HAC 5986-1	Label		

2.2 Labels and Plate Set

Article No	**Name**	**Foldout No**
3HAC 4724-1	**Part List**	**2:4**

Item	**Qty**	**Article No**	**Name of Item**	**Text on Label**	**Rem.**
1	2	3HAC 3981-1	Warning label	Stored energy	
2	4	3HAC 4431-1	Warning label	High temp.	
3	2	3HAC 4517-1	Warning label	Risk of squeezing	
4	1	3HAC 4591-1	Instruction label	Safety provisions	
7	1	3HAC 5089-1	ABB-logotype	Logotype	
9	3	3HAC 5127-1	ABB-logotype	Logotype	
12	1	3HAC 6029-1	Warning label	Brake release	
14	1	3HAC 4725-1	Instruction label	Lifting of robot	
15	2	3HAC 5020-1	Warning label	Risk of tipping	
16	5	3HAC 1589-1	Warning sign	Flash sign w. arrow	

2.3 Axis 1-3 Complete

Article No	Name	Foldout No
3HAC 4644-1	**Part List**	**2:5 - 2:6**

Item	Qty	Article No	Name of Item	Dimensions	Rem.
1	1	3HAC 4367-1	Gearbox 1-3 inc.base		**Spare part no.**
1.9	8	3HAC 4521-1	Oil Plug	R 1/2	
2	1	3HAC 4344-1	Lower arm System		
3	1	3HAC 4646-1	Motor 1 incl pinion		**Spare part no.**
4	1	3HAC 4648-1	Motor 2 incl pinion		**Spare part no.**
5	1	3HAC 4649-1	Motor 3 incl pinion		**Spare part no.**
6	1	3HAC 4615-1	Brake release unit		**Spare part no.**
7	35,5	1171 2016-604	Lubricating oil		
8	1	3HAC 3667-1	Mech.stop ax.1		
9	1	3HAC 3491-1	Harness manipulator		
10	1	3HAC 4532-1	Harness protecting cap		
11	1	3HAC 4553-1	Cover, harness cap axis 1		
12	32	3HAB 3409-86	Hex socket head cap screw	M16x60	
13	32	3HAA 1001-186	WASHER		
14	1	3HAC 4241-1	Connector plate complete		
15	1	3HAC 4680-1	Cover R1		**Spare part no.**
16	1	3HAC 4621-1	SMB and battery unit		
17	1	3HAC 4605-1	Cover unit, SMB		**Spare part no.**
30	1	3HAC 4810-4	Sync Bracket Axis 1		
31	1	3HAA 1001-73	Sync. plate, axis 1		
32	1	3HAC 4810-6	Sync Support Axis 1		
33	1	3HAC 4810-5	Calib. Bracket Axis 1		
34	1	3HAC 4810-1	Sync Bracket Axis 2		
35	2	3HAC 4832-1	Sync. plate with nonie		
36	1	3HAC 4832-2	Sync. plate Axis 2		
37	2	3HAC 4810-3	Sync Bracket Axis 2/3		
38	1	3HAC 4810-2	Sync Bracket Axis 3		
40	1	3HAC 4832-3	Sync. plate Axis 3		

Item	Qty	Article No	Name of Item	Dimensions	Rem.
42	1	3HAC 5172-1	Cable guide ax2		
43	1	3HAC 5500-1	Cover mech.stop 1		**Spare part no.**
100	54	9ADA 629-56	Torx pan head roll. screw	M6x16	
101	1	9ADA 183-108	Hex socket head cap screw	M20x90	
102	1	3HAC 3668-1	Compression spring		
103	1	3HAC 3669-1	Washer		
104	12	9ADA 183-50	Hex socket head cap screw	M10x25	
105	12	9ADA 312-8	Plain washer	10,5x20x2	
106	15	3HAB 7116-1	Adhesive		
108	1	3HAC 4670-1	Hose clamp, 120-140mm		
109	10	9ADA 618-32	Torx pan head screw	M4x8	
110	10	9ADA 312-4	Plain washer	4,3x9x0,8	

2.4 Lower arm System

Article No	**Name**	**Foldout No**
3HAC 4344-1	**Part List**	**2:7**

Item	**Qty**	**Article No**	**Name of Item**	**Dimen- sions**	**Rem.**
1	1	3HAC 3896-1	Lower arm		**Spare part no.**
2	1	3HAC 3898-1	Parallel arm		
3	1	3HAB 4169-1	Sealed spherical bearing		
4	1	3HAC 4310-1	Sealed spherical bearing		
5	2	3HAC 4444-1	Damper		
6	2	3HAC 4442-1	Damper axis 2		
7	2	3HAC 4443-1	Damper axis 3		
8	10	9ADA 629-56	Torx pan head roll. screw	M6x16	
10	1	1269 0014-429	Locking liquid		
11	1	3HAC 4435-1	Spacing sleeve		
12	1	3HAC 4458-1	Spacing sleeve		
13	10	3HAB 3537-1	Bearing grease		

2.5 Upper arm Complete

Article No	Name	Foldout No
3HAC 3973-1	**Part List**	**2:8 - 2:9**

Item	Qty	Article No	Name of Item	Dimension	Rem.
1	1	3HAC 4212-1	Axis 4, complete		
2	1	3HAC 3975-1	Wrist, complete		**Spare Part No**
3	1	3HAC 5441-1	Arm extension set		
3.102	8	3HAB 7700-69	Hex socket head cap screw	M12x50	
3.103	8	3HAA 1001-134	Washer		
3.104	1	9ABA 142-92	Spring pin, slotted	10x30	
3.105	2	3HAA 1001-297	Friction Washer		
3.1	1	3HAC 3963-1	Arm extension	345	**Spare part no.**
3.2	1	3HAC 3964-1	Arm extension	550	**Spare part no.**
4	1	3HAC 3492-1	Harness axis 5		
4	1	3HAC 4327-1	Harness axis 5, 680		
5	1	3HAC 3493-1	Harness axis 6, 790		
5	1	3HAC 4328-1	Harness axis 6, 1340		
6	8	3HAB 7700-69	Hex socket head cap screw	M12x50	
7	8	3HAA 1001-134	Washer		
8	1	9ABA 142-92	Spring pin, slotted	10x30	
9	6	9ADA 629-56	Torx pan head roll. screw	M6x16	
10	1	3HAC 4677-1	Lining		
11	1	1269 0014-429	Locking liquid		
12	2	3HAA 1001-297	Friction Washer		

2.6 Axis 4, Complete

Article No	Name	Foldout No
3HAC 4212-1	**Part List**	**2:10**

Item	Qty	Article No	Name of Item	Dimension	Rem
1	1	3HAC 4070-1	Motor incl pinion axis 4		**Spare part no.**
3	1	3HAC 4399-1	Axis 4 housing		**Spare part no.**
3	1	3HAC 3938-1	Axis 4 housing		**Spare part no.**
4	2	3HAA 1001-124	Support ring		
5	1	3HAC 4267-1	Upper arm, foundry		
5	1	3HAC 3774-1	Upper arm		**Spare part no.**
6	2	2213 253-5	Ball bearing	170x215x22	
7	1	2216 0086-4	Sealing (Nilos)	180x215x4	
8	1	3HAB 4317-1	SEALING		
9	1	3HAA 1001-628	Sealing		
10	1	2216 261-18	Sealing	170x200x15	
11	1	3HAA 1001-24	Gear		
11	1	3HAB 8460-1	Gear Z4/4		
12	1	3HAB 8508-1	Spacer		
13	1	3HAC 4209-1	Interm. wheel unit Z2,3/4		
14	3	3HAB 3409-62	Hex socket head cap screw	M10X100	
15	3	2154 2033-10	Spring washer	10,5x23x2,5	
16	3	2122 2011-465	Studs	M8X70	
17	3	3HAA 1001-99	Wedge		
18	3	9ADA 267-7	Hexagon nut	M8	
19	8	9ADA 312-7	Plain washer	8,4x16x1,6	
20	1	3HAA 1001-102	Stop axis 4, Upper arm		
21	2	9ADA 183-65	Hex socket head cap screw	M12x30	
22	1	3HAA 1001-100	Damper axis 4		
23	1	3HAA 1001-17	Stop Axis 4 Casting		
24	1	3HAA 1001-98	Gasket		
25	8	9ADA 183-37	Hex socket head cap screw	M8x25	
26	2	2522 122-1	Magnetic plug	R1/4"	

Item	Qty	Article No	Name of Item	Dimension	Rem
27	2	2152 0441-1	Washer	13,5x18x1,5	
28	1	3HAA 1001-33	Cover axis 4, machining		
29	1	3HAA 1001-97	Gasket		
30	12	9ADA 629-56	Torx pan head roll. screw	M6x16	
31	12	2154 2022-4	Spring washer	6,4x12x0,5	
32	1	3HAC 3774-7	Spacer ring		
33	1	3HAA 1001-76	Sync. plate axes 4		
34	1	3HAA 1001-79	Sync. plate with nonie		
35	4	9ADA 629-32	Torx pan head roll. screw	M4x8	
36	4	9ADA 312-4	Plain washer	4,3x9x0,8	
37	600 0	1171 2016-604	Lubricating oil		
38	2	2522 726-3	Protective hood	D=7,6 - 9,3	
39	1	1269 0014-429	Locking liquid		
40	1	1269 0014-407	Locking liquid		
41	30	3HAB 3537-1	Bearing grease		
42	1	3HAB 3772-27	O-ring	170x5	
43	12	2154 2033-9	Spring washer	8,4x18x2	
44	1	3HAC 3242-4	Fixing plate axis 3		
45	4	9ADA 629-56	Torx pan head roll. screw	M6x16	
46	2	3HAC 4444-1	Damper		
48	1	3HAC 4521-1	Oil Plug	R 1/2	

2.7 Wrist Complete

Article No	Name	Foldout No	Rem
3HAC 3975-1	**Part List**	**2:11**	**Spare Part no.**

Item	Qty	Article No	Name of Item	Dimension	Rem.
1	1	3HAC 0694-1	Wrist housing, machining		
2.1	1	3HAC 3605-1	Motor	2.5-120, 2,5-150 3.0-100	**Spare Part no.**
2.1	1	3HAC 3606-1	Motor	2.5-200, 2.8-200	**Spare Part no.**
2.3	1	2151 2012-430	O-ring		
3	4	9ADA 183-38	Hex socket head cap screw	M8x30	
4	4	9ADA 312-7	Plain washer	8,4x16x1,6	
5	1	3HAC 4072-1	Gear set unit Z1,2,3/5		
6	4	3HAB 3409-53	Hex socket head cap screw	M10x25	
7	1	3HAA 0001-AE	Set of Shims		
8	1	3HAB 4335-1	Set of shims		
10	1	3HAA 2167-15	Spherical roller bearing	D=52/25 B=18	
11	1	3HAA 1001-132	Deep Groove Ball Bearing		
12	1	3HAB 4333-1	Shaft		
13	6	9ADA 183-38	Hex socket head cap screw	M8x30	
14	1	3HAB 7299-1	SEALING	Di=115 Dy=140 B=12	
16	1	2158 0399-4	End lid	D=120	
17	8	3HAA 1001-106	Washer		
18	1	3HAA 1001-266	Screw		
19	1	3HAA 1001-267	Washer		
20	4	2122 2011-465	Studs	M8X70	
21	4	3HAA 1001-99	Wedge		
22	4	9ADA 267-7	Hexagon nut	M8	
23	2	3HAB 4337-1	Damper axis 5		
24	8	9ADA 629-56	Torx pan head roll. screw	M6x16	
25	2	2522 122-1	Magnetic plug	R1/4"	
26	2	2152 0441-1	Washer	13,5x18x1,5	

27	2	9ADA 629-56	Torx pan head roll. screw	M6x16	
28	1	3HAA 1001-112	Gasket		
29	1	3HAA 1001-79	Sync. plate with nonie		
30	2	9ADA 629-32	Torx pan head roll. screw	M4x8	
31	11	9ADA 629-56	Torx pan head roll. screw	M6x16	
32	1	3HAC 3974-1	Motor incl gearbox axis 6		**Spare Part no.**
33	12	3HAB 3409-57	Hex socket head cap screw	M10x60	
33	12	3HAB 3409-73	Hex socket head cap screw	M12x70	
34	1	3HAC 4085-1	Gear unit Z6/5		
35	2	9ADA 312-4	Plain washer	4,3x9x0,8	
36	11	2154 2022-4	Spring washer	6,4x12x0,5	
37	1	3HAC 4084-1	Interm. Wheel Unit Z4,5/5		
38	1	3HAB 4384-1	Cover axis 5, anodized		**Spare Part no.**
38	1	3HAB 9326-1	Cover, anodized		**Spare Part no.**
39	1	1269 0014-429	Locking liquid		
40	1	1269 0014-413	Locking liquid		
41	6	1171 2016-604	Lubricating oil		
41	6,5	1171 2016-604	Lubricating oil		
43	16	2154 2033-9	Spring washer	8,4x18x2	
44	2	9ADA 312-6	Plain washer	6,4x12x1,6	
45	4	3HAB 4233-1	Washer		
48	1	1234 0011-116	Flange sealing		
49	2	9ADA 618-55	Torx pan head screw	M6x12	
50	1	3HAC 0767-1	Locking washer	D=31 T=2	

2.8 Motor incl. gearbox axis 6

Article No	Name	Foldout No
3HAC 3974-1	**Part List**	**2:12**

Item	Qty	Article No	Name of Item	Dimension	Rem.
1	1	3HAC 3609-1	Motor	2.5-120, 2.5-150 2.8-150, 3.0-100	**Spare Part no.**
1	1	3HAC 3610-1	Motor	2.5-200, 2.8-200	**Spare Part no.**
2	1	2152 0431-12	O-ring	151,99x3,53	
3	1	3HAB 5593-1	Reduction gear RV-30E-81		
3	1	3HAC 4594-1	Reduction gear RV-30E-81		
4	8	3HAB 3409-40	Hex socket head cap screw	M8x40	
5	1	9ADA 183-21	Hex socket head cap screw	M5x50	
6	8	3HAA 1001-172	Washer		
7	1	2522 122-1	Magnetic plug	R1/4"	
8	1	2152 0441-1	Washer	13,5x18x1,5	
9	1	3HAA 1001-77	Sync. plate,axis 5		
10	1	3HAA 1001-78	Sync. plate, axis 6		
11	1	3HAA 1001-174	Sync. plate		
12	4	9ADA 629-32	Torx pan head roll. screw	M4x8	
13	4	9ADA 312-4	Plain washer	4,3x9x0,8	
14	300	3HAC 2331-1	Grease		
15	1	1269 0014-410	Locking liquid		

2.9 Balancing Unit

Article No	Name	Foldout No
3HAC 4724-1	**Part List**	**2:13**

Item	Qty	Article No	Name of Item	Text on Label	Rem.
1	1	3HAC 4530-1	Cylinder w attachment		
2	1	3HAC 3574-1	Piston		
3	1	3HAC 3565-1	Flange		
4	1	3HAC 3611-1	Compression spring A/B		
5	1	3HAC 3883-1	Compression spring innerB		
6	1	3HAC 3476-1	Guiding ring		
7	1	3HAC 3532-1	Lining		
8	2	3HAC 3311-1	Adjust. Needle Bearing		
9	4	3HAC 3567-1	Protective hood		
10	1	3HAC 3530-1	Circlip		
11	1	3HAC 3614-1	Marking plate B		
12	2	2522 2101-5	Protection hood	D=9,2-10,8	
13	1	9ADA 618-55	Torx pan head screw	M6x12	

2.10 Fan Axis 1 Complete

Article No	**Name**	**Foldout No**
3HAC 4811-1	**Part List**	**2:14**

Item	Qty	Article No	Name of Item	Dimension	Rem.
1	1	3HAC 4106-1	Radial fan		
2	1	3HAC 5213-1	Holder		
3	1	3HAC 5180-1	Housing		
4	7	9ADA 629-56	Torx pan head roll. screw	M6x16	
5	3	9ADA 629-59	Torx pan head roll. screw	M6x30	
6	1	3HAA 1001-607	GASKET		
7	1	3HAC 6255-1	Fan cable		
8	2	2166 2055-3	Cable straps, outdoors	4,8x208	

2.11 Position Switch Axis1

Article No	Name	Foldout No
3HAC 4702-1,2,3	**Part List**	**2:15**

Item	Qty	Article No	Name of Item	Dimension	Rem.
1	1	3HAC 4704-1	Pos SW 1 function		
1	1	3HAC 4705-1	Pos SW 2 functions		
1	1	3HAC 4706-1	Pos SW 3 functions		
2	1	3HAC 5183-1	Rail axis 1, entrance		
3	1	3HAC 5184-1	Rail axis 1		
4	1	3HAC 5414-1	Cam kit ax1:1		
5	6	3HAC 4735-1	Rail bracket axis 1		
6	1	3HAC 4766-1	Connector bracket R1.SW1		
7	4	3HAC 4798-1	Tension pin		
8	26	9ADA 618-56	Torx pan head screw	M6x16	
9	1	3HAC 5437-1	Mitre box 30deg		
10	1	3HAC 5439-1	Cable bracket R1.SW1		
11	2	3HAC 4839-1	Protection sheet axis 1		
12	1	9ADA 183-81	Hex socket head cap screw	M16x35	
13	1	2969 105-12	Bag	600x200x800x0, 10	

2.12 Position Switch Axes 2

Article No	Name	Foldout No
3HAC 4716-1	**Part List**	**2:16**

Item	Qty	Article No	Name of Item	Dimension	Rem.
1	1	3HAC 5435-1	Pos SW 1 functions		
2	1	3HAC 4693-1	Plate with spacer axis 2		
3	1	3HAC 5422-1	Cam kit ax2		
4	1	3HAC 5185-1	Rail axis 2		
5	2	3HAC 4398-1	Bracket		
6	4	9ADA 618-56	Torx pan head screw	M6x16	
7	4	9ADA 618-57	Torx pan head screw	M6x20	
8	4	9ADA 618-65	Torx pan head screw	M6x60	
9	1	3HAC 5437-1	Mitre box 30deg		

2.13 Position Switch Axes 3

Article No	Name	Foldout No
3HAC 4723-1	**Part List**	**2:17**

Item	Qty	Article No	Name of Item	Dimension	Rem.
1	1	3HAC 5436-1	Pos SW 1 functions axis 3		
2	1	3HAC 5186-1	Rail axis 3		
3	1	3HAC 5423-1	Cam kit ax3		
4	3	3HAC 4609-1	Rail bracket axis 3		
5	12	9ADA 618-56	Torx pan head screw	M6x16	
6	1	3HAC 5437-1	Mitre box 30deg		

2.14 Signal Lamp

Article No	Name	Foldout No
3HAC 4804-1	**Part List**	**2:18**

Item	Qty	Article No	Name of Item	Dimension	Rem.
1	1	3HAC 2552-1	Lamp		
2	1	3HAC 2987-1	Lamp Holder		
3	1	3HAB 3772-21	O-ring		
4	1	3HAC 4909-1	Bracket, signal lamp		
5	1	3HAC 4772-2	Cable gland (tabular dr.)	Pg7 (Pr12,5) 4,0-7,0	
6	1	3HAC 4772-3	Cable gland (tabular dr.)	Pg9 (Pr15,2) 4,0- 6,0	
7	2	5217 649-87	Connector		
8	2	5217 649-70	Pin	0.5-0.75 mm2	
9	1100	3HAC 3198-1	Cable	3 x AWG20	
10	2	9ADA 629-56	Torx pan head roll. screw	M6x16	
11	2	2166 2055-3	Cable straps, outdoors	4,8x208	

2.15 Forklift Set

Article No	Name	Foldout No
3HAC 4765-1	**Part List**	**2:1**

Item	Qty	Article No	Name of Item	Dimension	Rem.
100	2	3HAC 4364-1	Fork Lift Device		
100.1	8	3HAA 1001-186	WASHER		
100.2	8	3HAB 3409-86	Hex socket head cap screw	M16x60	

2.16 Onboard Calibration

Article No	Name	Foldout No
3HAC 6360-1	**Part List**	**2:19 - 2:20**

Item	Qty	Article No	Name of Item	Dimension	Rem.
1	1	3HAC 6014-1	Inductive switch set		
2	0	3HAC 6004-1	Sync.tool		
3	1	3HAC 3659-1	Parallel key		
4	1	3HAC 3763-1	Parallel key		
5	1	3HAC 4470-1	Parallel key		
6	10	1234 0011-109	Acrylate adhesive		

2.17 Process Media Conduit

Article No	Name	Foldout No
3HAC 6018-10	**Part List**	**2:21**

Item	Qty	Article No	Name of Item	Dimension	Rem.
1	1	3HAC 6018-1	Lower process media guide		
2	1	3HAC 6018-8	Attachment, p.media guide		
3	1	3HAC 6018-9	Attachment, p.media guide		
4	18	9ADA 629-56	Torx pan head roll. screw	M16x16	
5	8	9ADA 312-6	Plain washer	6,4x12x1,6	
6	4	3HAC 6018-13	Spacer		
7	1	3HAC 6018-2	Upper process media guide		
8	2	3HAC 6018-3	Attachment profile		
9	1	3HAC 6018-11	Attachment, p.media guide		
10	4	6355 0004-HF	Hose Clamp 80		
11	8	9ADA 183-35	Hex socket head cap screw	M8x16	
12	1	3HAC 6018-20	Material set, support arm		
13	1	3HAC 4731-5	Welding Bracket Side		
14	1	3HAC 4731-6	Welding Bracket on Frame		

15	2	s 9ADA 183-71 t	Hex socket head cap screw	M12x60
16	2	s 9ADA 312-9 t	Plain washer	13x24x2,5
17	1	m3HAB 7116-1 l	Locking liquid	
18	2	s 9ADA 267-9 t	Hexagon nut	M12
19	1	s 3HAC 4731-3 t	Welding Bracket Lower Arm	
20	4	s 9ADA 183-54 t	Hex socket head cap screw	M10x45
21	1	s 3HAC 6018-14 t	Attachment, p.media guide	
22	4400	m3HAC 5320-1 m	Protection hose	Di=67mm Dy=80mm
23	2	s 9ADA 183-49 t	Hex socket head cap screw	M10x20
24	5	s 3HAC 4127-8 t	Counters. hex head screw	M8x25
25	2	s 3HAC 4738-1 t	Welding Cable Clamp	

2.18 Harness

Item	**Qty**	**Article No**	**Name of Item**	**Dimension**	**Rem.**
4	1	3HAC 3492-1	Harness axis 5		
4	1	3HAC 4327-1	Harness axis 5	680	
5	1	3HAC 3493-1	Harness axis 6	790	
5	1	3HAC 4328-1	Harness axis 6	1340	
9	1	3HAC 3491-1	Harness manipulator		
10	1	3HAC 4532-1	Harness protecting cap		
108	1	3HAC 3495-1	Harness CP/CS ax4		
108	1	3HAC 3494-1	Harness CP/CS ax3		
110	1	3HAC 3496-1	SWeld Harness 25/3 int.		

3 Spare Part List Manipulator

3.1 Manipulator

Drawing number 3HAC 3972-1

Item	Number	Actions and Supplements	Spare P. Number
Fan Axis 1	3HAC 4106-1	Painted	
Cap	3HAC 5180-1	Painted	
Parallel Arm + Bearings	3HAC 4058-1	Painted	3HAC 7169-1
Balancing Unit	3HAC 3608-1	Painted, Labels 3HAC 3981-1 Mounting Details pos. 209,230,231,232,233	3HAC 6964-1
Balancing Unit	3HAC 4219-1	Painted, Labels 3HAC 3981-1 Mounting Details pos. 209,230,231,232,233	3HAC 6967-1
Balancing Weight 154 kg	3HAC 3902-1	Painted, Labels 3HAC 4517-1, 3HAC5089-1 Screw pos. 240 and pos 241	3HAC 7019 -1
Balancing Weight 309 kg	3HAC 4103-1	Painted, Labels 3HAC 4517-1, 3HAC5089-1 Screw pos. 240 and pos 241	3HAC 7020-1
Balancing Weight 458 kg	3HAC 4129-1	Painted, Labels 3HAC 4517-1, 3HAC5089-1 Screw pos. 240 and pos 241	3HAC 7021-1

3.2 Axis 1-3 Complete

Drawing number 3HAC 4644-1

Item	Number	Actions and Supplements	Spare P. Number
Gear Box	3HAC 4367-1	Painted	3HAC 7149-1
Gear Box	3HAC 4367-1	Sealings, VK Cover	
Gear Box	3HAC 4367-1	Oil Pipe	
Lower Arm	3HAC 4344-1	Painted, Labels 3HAC 4725-1/3HAC 5127-1	3HAC 7150-1
Motor 1 + Pinion	3HAC 4646-1	Painted, Labels 3HAC 4431-1 + 3HAC 1589-1	3HAC 6930-1
Motor 2 + Pinion 100-150kg	3HAC 4648-1	Painted, Labels 3HAC 4431-1 Motor 3HAC 3600-1+ Pinion 3HAC 4520-1	3HAC 6931-1
Motor 2 + Pinion 200kg	3HAC 4648-1	Painted, Labels 3HAC 4431-1 Motor 3HAC 3602-1+ Pinion 3HAC 4520-1	3HAC 6933-1

Motor 3 + Pinion 100-120kg	3HAC 4649-1	Painted, Labels 3HAC 4431-1 Motor 3HAC 3599-1+ Pinion 3HAC 4520-1	3HAC 6934-1
Motor 3 + Pinion 150-200kg	3HAC 4649-1	Painted, Labels 3HAC 4431-1 Motor 3HAC 3602-1+ Pinion 3HAC 4520-1	3HAC 6935-1
Break release unit	3HAC 4615-1	Cover+Card	Yes
Cover R1	3HAC 4680-1	Painted	3HAC 7126-1
Cover Mechanical Stop	3HAC 5500-1	Painted	3HAC 7165-1
Cover SMB	3HAC 4605-1	Painted, with Sealing	3HAC 7166-1

3.3 Upper Arm Complete

Drawing number 3HAC 3973-1

Item	**Number**	**Actions and Supplements**	**Spare Part No.**
Motor Ax.4 + Pinion	3HAC 4070-1		
Motor Ax.4 100-150 kg	3HAC 4070-1	Painted, Labels. Motor 3HAC 3605-1+ Pinion 3HAC 4520-1	3HAC 6936-1
Motor Ax.4 200 kg	3HAC 4070-1	Painted, Labels. Motor 3HAC 3606-1+ Pinion 3HAC 8418-1	3HAC 6937-1
Axis 4 Housing	3HAC 3938-1	Painted	
Axis 4 Housing	3HAC 4399-1	Painted	3HAC 7126-1
Cover Axis 4	3HAC 4807-1	Painted+pos. 253 and pos. 254	3HAC 7015-1
Upper Arm	3HAC3774-1	Painted	
Arm Extender 345	3HAC 3963-1	Painted + pos. 102-105	3HAC 7134-1
Arm Extender 550	3HAC 3964-1	Painted + pos. 102-105	3HAC 7135-1
Cover Axis 4	3HAA 1001-33	Painted	
Wrist	3HAC 3975-1	Tested, Painted, Label 3HAC 5127-1 + pos. 6,7,8,11,12	
Wrist 150 kg		Motor 3HAC 3609-1 + 3HAC 5927-1 + 3HAC 3605-1	3HAC 6668-1
Wrist 150 kg Insulated		Motor 3HAC 3609-1 + 3HAC 5928-1 + 3HAC 3605-1	3HAC 6668-2
Wrist 200 kg		Motor 3HAC 3610-1 + 3HAC 5927-1 + 3HAC 3606-1	3HAC 6668-3
Wrist 200 kg Insulated		Motor 3HAC 3610-1 + 3HAC 5928-1 + 3HAC 3606-1	3HAC 6668-4
Motor Axis 5 100-150 kg	3HAC 3605-1		
Motor Axis 5 200 kg	3HAC 3606-1		

Motor Axis 6 + Pinion	3HAC 3974-1		Yes
Motor Ax. 6 + Pinion 100-150 kg		Painted, (Motor 3HAC 3609-1 + 3HAC 5927-1)	3HAC 6938-1
Motor Axis 6 + Pinion 100-150 kg Insulated		Painted, (Motor 3HAC 3609-1 + 3HAC 5928-1)	3HAC 6940-1
Motor Axis 6 + Pinion 200 kg		Painted, (Motor 3HAC 3610-1 + 3HAC 5927-1)	3HAC 6942-1
Motor Axis 6 + Pinion 200 kg Insulated		Painted, (Motor 3HAC 3610-1 + 3HAC 5928-1)	3HAC 6943-1
Motor Axis 6	3HAC 3609-1	Painted	3HAC 7156-1
Motor Axis 6	3HAC 3610-1	Painted	3HAC 7157-1
Cover Axis 5 100-150 kg	3HAB 4384-1	Painted, Label 3HAC 5127-1	3HAC 7016-1
Cover 200 kg	3HAB 9326-1	Painted, Label 3HAC 5127-1	3HAC 7017-1

3.4 Miscellaneous

Item	Number	Actions and Supplements	Spare P. Number
Cover	3HAB 7070-1	Painted	3HAC 7130-1
Cover	3HAC 4547-1	Painted	3HAC 7129-1
Cover	3HAC 4674-1	Painted	3HAC 7128-1
Cover	3HAC 4675-1	Painted	3HAC 7127-1

4 Part List / Spare Parts Controller

4.1 Cabinet

Article No	Name
3HAC 3803-1	**Part List**

Item	Qty	Article No	Name of Item	Rem
2	1	3HAC 0927-2	Air filter clips	

4.2 Basic Equipment

Article No	Name
3HAC 3011-1	**Part List**

Item	Qty	Article No	Name of Item	Rem
5	1	3HNM 00032-1	Holder for Teach Pendant	
6	1	3HAB 2480-1	Floppy Disc Drive	
9	1	3HAB 7215-1	Panel board set DSQC 331	
11	1	3HAC 6647-1	Duty time counter	

4.3 Operators Panel

Article No	Name
3HAC 3101-1	**Part List**

Item	Qty	Article No	Name of Item	Rem
1	1	3HAB 7818-1	Actuator tranparent	
5	1	5911 069-10	Filament lamp	

Article No	Name
3HAC 2355-1	**Part List**

Item	Qty	Article No	Name of Item	Rem
1	1	3HAC 2349-1	Filament lamp	
7	1	3HAB 5171-1	Emergency stop	
9	1	SK 616 003-A	Lamp block	
10	2	SK 616 001-A	Contact block	
16	1	3HAB 5171-1	Emergency pushbutton	

Article No	Name
3HAC 3132-1	**Part List**

Item	Qty	Article No	Name of Item	Rem
1	1	3HAC 3116-1	Cam Switch	

4.4 Mains

Article No	Name
3HAC 2412-1	**Part List**

Item	Qty	Article No	Name of Item	Rem
12	1	3HAC 2406-1	Door Interlock NA-Switch	
14	1	3HAC 3577-1	Circuit breaker	

Article No	Name
3HAC 2834-1	**Part List**

Item	Qty	Article No	Name of Item	Rem
1	1	3HAB 5142-1	3-phase main switch	
10	1	3HAB 8037-1	Door Interlock	

Article No	Name
3HAC 4803-1	**Part List**

Item	Qty	Article No	Name of Item	Rem
2	3	3HAC 4802-1	Fuse	

Article No	Name
3HAC 0831-1	**Part List**

Item	Qty	Article No	Name of Item	Rem
1	1	3HAB 2017-7	Miniature circuit breaker	

Article No	Name
3HAC 0779-1	**Part List**

Item	Qty	Article No	Name of Item	Rem
1	1	3HAB 2017-4	Safety breaker	

4.5 Transformer

Article No	Name
3HAC 7199-18	**Part List**

Item	Qty	Article No	Name of Item	Rem
2	1	3HAB 8101-1	Modules Drive System	DSQC 346U

Article No	Name
3HAC 4815-1	**Part List**

Item	Qty	Article No	Name of Item	Rem
2	1	3HAB 8101-14	Modules Drive System	DSQC 345E
9	1	3HAB 7362-1	Fan unit	
	1	3HAB 7311-1	Fan	

Article No	Name
3HAC 3873-1	**Part List**

Item	Qty	Article No	Name of Item	Rem
1	1	3HAB 4951-1	Transformer unit T5	T5, 200-440V
1	1	3HAC 3876-1	Transformer unit T5	T5, 400-500V
1	1	3HAC 4953-1	Transformer unit T5	T5, 475-600V

Article No	Name
3HAC 1477-1	**Part List**

Item	Qty	Article No	Name of Item	Rem
1	1	3HAC 1475-1	Mains line filter	

Article No	Name
3HAC 7308-1	**Part List**

Item	Qty	Article No	Name of Item	Rem
1	1	3HAB 1475-1	Mains line filter	IRB 4400, 64XX

Article No	Name
3HAC 7067-1	**Part List**

Item	Qty	Article No	Name of Item	Rem
1	1	3HAB 7067-1	Electronic Time Relay	

4.6 Teach Pendant

Article No	Name
3HAC 3901-1	**Part List**

Item	Qty	Article No	Name of Item	Rem
1	1	3HNE 00313-1	Prog.Unit, W/Backlight	
2	1	3HNE 00133-1	Extension Cable for TPU	10 m
	1	3HNE 00188-1	Teach pendant cable	10 m

4.7 Cables to Manipulator

Article No	Name
3HAC 4936-1	**Part List**

Item	Qty	Article No	Name of Item	Rem
1	1	3HAC 4717-5	Control cable power	L=22 m
2	1	3HAC 2540-1	Control cable signal	L=22 m

Article No	Name
3HAC 4934-1	**Part List**

Item	Qty	Article No	Name of Item	Rem
1	1	3HAC 4417-4	Control cable power	L=15 m
2	1	3HAC 2530-1	Control cable signal	L=15 m

Article No	Name
3HAC 4936-1	**Part List**

Item	Qty	Article No	Name of Item	Rem
1	1	3HAC 5548-2	Control cable power	L=15 m Braided
2	1	3HAC 3345-1	Control cable signal	L=15 m Braided

Article No	Name
3HAC 4937-1	**Part List**

Item	Qty	Article No	Name of Item	Rem
1	1	3HAC 4417-6	Control cable power	L=30 m
2	1	3HAC 2566-1	Control cable signal	L=30 m

Article No	**Name**
3HAC 4933-1	**Part List**

Item	Qty	Article No	Name of Item	Rem
1	1	3HAC 4417-1	Control cable power	L=7 m
2	1	3HAC 2493-1	Control cable signal	L=7 m

Article No	**Name**
3HAC 4938-1	**Part List**

Item	Qty	Article No	Name of Item	Rem
1	1	3HAC 5548-1	Control cable power	L=7 m Braided
2	1	3HAC 3344-1	Control cable signal	L=7 m Braided

Article No	**Name**
3HAC 3836-1	**Part List**

Item	Qty	Article No	Name of Item	Rem
1	1	3HAC 3379-1	Pos. switch cable	L=15 m
1	1	3HAC 3380-1	Pos. switch cable	L=22 m
1	1	3HAC 3381-1	Pos. switch cable	L=30 m
1	1	3HAC 3378-1	Pos. switch cable	L=7 m
3	1	3HAC 4948-2	Pos. switch cable Axes2/3	L=15 m
3	1	3HAC 4948-3	Pos. switch cable Axes2/3	L=22 m
3	1	3HAC 4948-4	Pos. switch cable Axes2/3	L=30 m
3	1	3HAC 4948-1	Pos. switch cable Axes2/3	L=7 m

Article No	Name
3HAC 3861-1	**Part List**

Item	Qty	Article No	Name of Item	Rem
1	1	3HAC 4947-2	CP, CS, CAN Cable	L=15 m
1	1	3HAC 4947-3	CP, CS, CAN Cable	L=22 m
1	1	3HAC 4947-4	CP, CS, CAN Cable	L=30 m
1	1	3HAC 4947-1	Can Bus/Cust Power	L=7 m

4.8 I/O Interfaces

Article No	Name
3HAC 4048-1	**Part List**

Item	Qty	Article No	Name of Item	Rem
1		3HAC 9742-1	Dig. 24VDC I/O Modul	DSQC 328
2		3HAC 1512-1	Analog I/O Unit	
3		3HAC 9741-1	A D Combi I/O Modul	DSQC 327
4		3HAB 9746-1	Dig.120VAC I/O Unit	DSQC 320
5		3HAB 9745-1	Dig. with relays I/O Unit	DSQC 332

Article No	Name
3HAC 4104-1	**Part List**

Item	Qty	Article No	Name of Item	Rem
1	1	3HAC 0070-1	RIO Unit	
2		3HAC 1495-1	Interbus-S Slave set	
3		3HAC 1785-1	Profibus DP Slave set	
4		3HAB 1701-1	ENC unit	
6	1	3HAB 2183-1	Profibus M/S DSQC 368	

Article No	Name
3HAC 4047-1	**Part List**

Item	Qty	Article No	Name of Item	Rem
4	1	3HAC 7216-1	Mounting set I/O pos. 1, 2	
4	1	3HAC 7636-1	Mounting set I/O pos. 1 - 4	

4.9 Computers and Disk Drive

Article No	Name
3HAC 4061-1	**Part List**

Item	Qty	Article No	Name of Item	Rem
2	1	3HAB 5957-1	Memory Expansion DSQC 324	16 MB
2	1	3HAB 5956-1	Memory Expansion DSQC 323	8 MB

Article No	Name
3HAC 4664-1	**Part List**

Item	Qty	Article No	Name of Item	Rem
1	1	3HNE 00001-1	Circuit board NIOC	DSQC 336

Article No	Name
3HAC 4568-1	**Part List**

Item	Qty	Article No	Name of Item	Rem
2	1	3HAC 2424-1	BackPlane	DSQC 369
14	1	3HAC 1620-1	Power supply	DSQC 365
21	1	3HAC 3180-1	Robot Computer	DSQC 373
23	1	3HAC 0373-1	Main Computer	DSQC 361

Article No	Name
3HAC 4568-1	**Part List**

Item	Qty	Article No	Name of Item	Rem
	1	3HAC 6478-1	Floppy disk cable	DSQC 369
14	1	3HAC 7239-3-1	Cover with cooler	DSQC 365